DUCK PRODUCTION STUDIES ON THE PRAIRIE POTHOLES OF SOUTH DAKOTA

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DUCK PRODUCTION STUDIES ON THE PRAIRIE POTHOLES OF SOUTH DAKOTA

By

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The grasslands in the glaciated portions of the Dakotas and western Minnesota, along with the Prairie Provinces of Canada, have long been recognized as prime waterfowl breeding habitat. There, the uneven glacial deposits have created rolling uplands almost unaffected by natural drainage. Because the drainage is slight and the soil heavy, nearly every depression holds water in spring. The water areas vary from small, temporary puddles to lakes of many hundred acres; these areas may number up to a hundred or more to the square mile and are often spoken of as "potholes."

Depending on the character of the glaciation and its age, the potholes in a particular area may be predominantly large and shallow, small and deep, or more or less heterogeneous. In some parts of the glaciated prairies, water is a critical item, and most of the ponds are dry at the end of a "normal" summer. In other parts, it is extremely rare for all to go dry. Owing to the high fertility of most of the glacial deposits, there is an abundance of plant and animal food for waterfowl.

The extent of the glaciated upland prairies of the Dakotas and Minnesota is shown in figure 1. It has been estimated (Nord et al. 1951) that more than 9 percent of the continental waterfowl production comes from these regions. In times past, the extent of productive breeding habitat was considerably larger. Drainage of land for agricultural use has eliminated all but a small percentage of the water areas in Iowa and southwestern Minnesota, where more even topography, better soils, and greater accessibility made drainage more profitable.

Since 1945, drainage has been greatly accelerated by the stimulus of high farm prices and by the encouragement of the Department of Agriculture through technical assistance and direct payments to farmers. These stimuli have brought the drainage program into the rolling upland regions shown in figure 1. In these regions, previously little affected by drainage, Nord and associates (1951) estimated for the years 1945 to 1950 an annual loss of 2 percent of the original water areas.

Largely through the efforts of F. T. Staunton, then Manager of the Waubay National Wildlife Refuge, and D. H. Janzen, Regional Director, the Fish and Wildlife Service became concerned with the problem. In 1950 a project was initiated by the Office of River Basin Studies to "determine the extent, distribution, and numbers of small water areas formerly and now present in the prairie pothole region of the Dakotas and Minnesota; to determine their importance to wildlife, the factors bringing about their disappearance, and to develop, if possible, methods for their preservation, if that appears warranted."

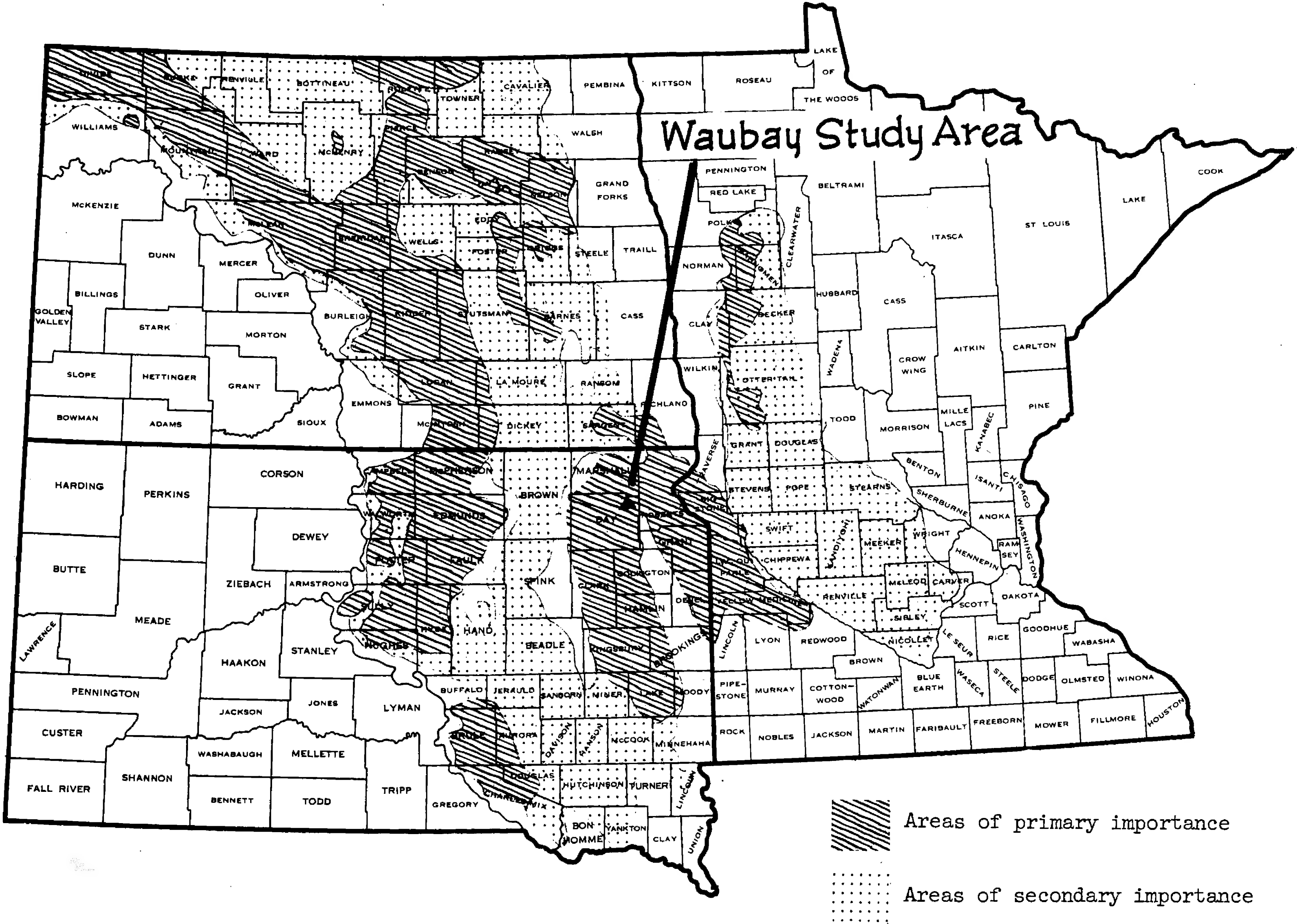

Figure 1.--MAJOR DUCK-PRODUCTION AREAS OF THE PRAIRIE POTHOLE REGION IN THE UNITED STATES

Knowledge of the relations of waterfowl to the habitat in that region was incomplete, and it was decided to initiate as part of the project a complete study of the waterfowl use of, and production from, a block area as nearly as possible representative of such habitat. With the aid of Mr. Staunton, an area was selected in the vicinity of Waubay, South Dakota, in May 1950.

DESCRIPTION OF THE AREA

Location

The study area (fig. 1) is in Day County, one of the northeastern counties of the State, 50 miles east of Aberdeen, South Dakota, and 13 miles north of Waubay on U.S. Route 12. It includes 11.25 square miles.

The area was selected to represent, as nearly as possible, "typical pothole country" as found in parts of the glaciated prairies of the Dakotas, Minnesota, and Canada.

Topography and soils

The study block, shown in figure 2, lies about 1,900 feet above sea level in an area of rolling upland between the James and Minnesota River valleys. This region is described by Rothrock (1935) as the Prairie Coteau, which consists of glacial deposits high in lime. Under native prairie grasses, these deposits have developed fertile soils, predominately dark, grayish-brown silt loams and silty clay loams (Westin et al. 1951). These vary considerably in depth and slope, as well as in the underlying material, which consists mainly of silts and clays. There are a few local gravel and sand outwash deposits.

Although most of the soils are highly productive, much of the land is rather steep, varying from undulating (3 to 4 percent slope) to hilly (18 percent slope and steeper). Some is too steep and stony for cultivation, and some is even too rough for cutting hay. Most is highly susceptible to erosion when cultivated, and in the years since it was first broken up its productivity has been severely reduced. As pointed out by Paul Underwood, then Soil Conservation Service farm planner, the ultimate future of this land lies in a grassland economy.

Climate

Temperatures of the region are summarized in table 1; the maximum and minimum temperatures for the breeding season (April 15-June 14) are shown in figure 3. Warm summers and cold winters are usual, with moisture in the subhumid range as shown in table 2. Most of the moisture falls in the growing season, and small grains are the predominant crop. Precipitation during the period of the study, except for 1953, was below the long-term average, but the character of the runoff was such that water levels were well above normal. In 1952, the year with the lowest precipitation, water levels in the region were at their highest point in 40 years, according to local residents.

Table 1.--Weather summary from Webster, South Dakota, 1901-38

[U.S.D.A. (1941); 16 miles from the study area]

January average temperature	9.2°F.
July average temperature	70.1°F.
Maximum temperature	108°F.
Minimum temperature	-44°F.
Average last killing frost in spring	May 16.
Average first killing frost in fall	Sept. 25.
Average growing season	132 days.

Table 2.--Precipitation in vicinity of study area, by months, 1950-53

[In inches. January 1950 - April 1951 from Webster, S. Dak., weather station; May 1951 - April 1952 from Roslyn weather station; May 1952 - December 1953 from Waubay National Wildlife Refuge weather station.]

	1950	1951	1952	1953	4-year average	1901-53 average
January	0.89	0.33	0.82	1.45	0.87	0.48
February	.05	.44	1.25	.70	.61	.48
March	1.27	1.11	.55	.23	.79	.85
April	.76	.89	.87	3.92	1.61	1.87
May	3.24	2.17	1.64	2.67	2.43	2.61
June	.98	3.91	4.41	6.84	4.04	3.82
July	6.37	3.98	1.90	2.85	3.78	3.09
August	2.56	2.60	.39	1.83	1.85	3.11
September	1.17	.45	.51	.15	.57	2.19
October	1.39	2.75	.01	.45	1.15	1.34
November	.54	.19	.78	1.64	.79	.70
December	.39	1.03	.55	.59	.64	.47
Total	19.61	19.85	13.68	23.32	19.13	21.01

Upland vegetation

The native upland vegetation of the region is true prairie as described by Weaver and Clements (1938) and consists mainly of midgrasses such as porcupine grass (*Stipa spartea*), dropseed (*Sporobolus asper* and *S. heterolepis*), little bluestem (*Andropogon scoparius*), prairie June grass(*Koeleria cristata*), bluestem wheatgrass (*Agropyron smithii*), and sideoats grama (*Bouteloua curtipendula*). On some pastures and high areas there are some of the short-grass species such as blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*). In addition, some of the hay land has been seeded to introduced species. In some locations, particularly on steeper slopes, wolfberry (*Symphoricarpos occidentalis*) is dominant. Tree growth is limited to a few willows (*Salix* spp.), cottonwoods (Populus deltoides), and occasional aspens (*Populus tremuloides*) on lowland sites, and to a few planted woodlots.

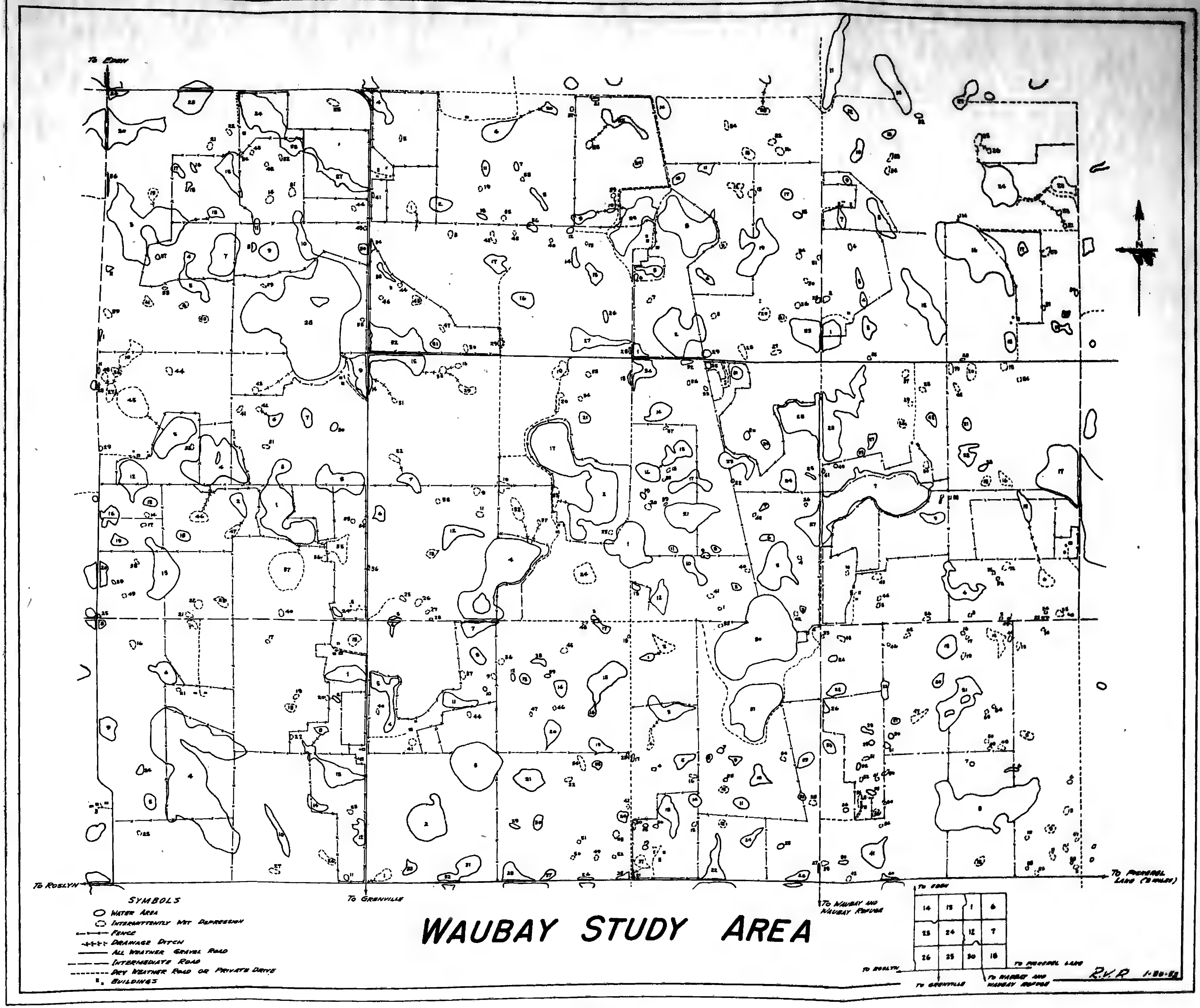
To Eden
To Roslyn
To Grenville
To Waubay and Waubay Refuge
To Pickerel Lake (3 miles)
SYMBOLS
Water Area
Intermittently Wet Depression
Fence
Drainage Ditch
All Weather Gravel Road
Intermediate Road
Dry Weather Road or Private Drive
Buildings
WAUBAY STUDY AREA
R.V.R.

FIGURE 2.

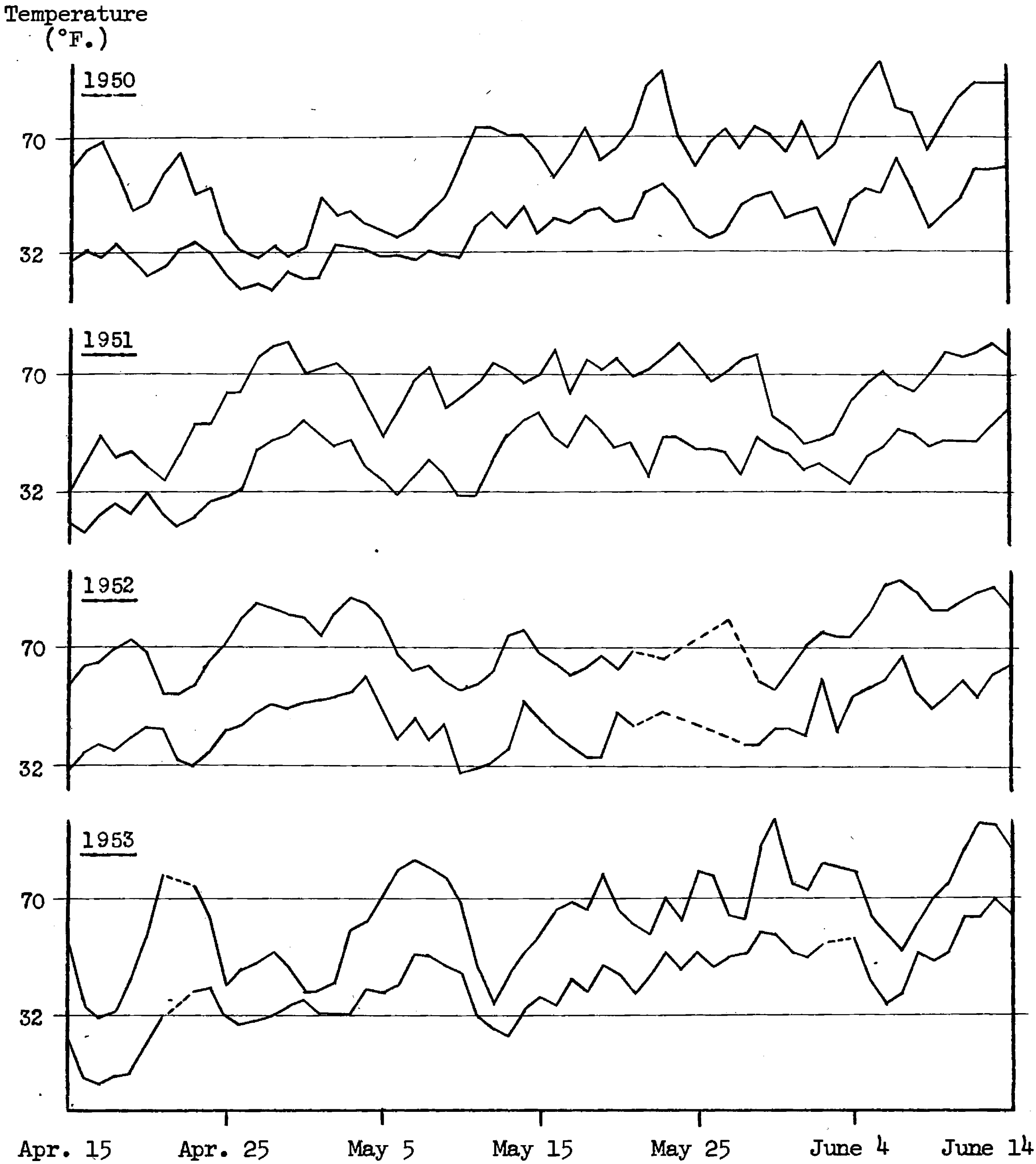

Figure 3.--MAXIMUM AND MINIMUM TEMPERATURES OF THE BREEDING SEASON, WAUBAY STUDY AREA, 1950 to 1953
(Dotted lines indicate incomplete data.)

Wetland vegetation

The vegetation of the potholes themselves is extremely variable. Some of the most temporary water areas contain mainly dryland species, while open waters in some of the deeper potholes contain submerged plants. Emergents are usually found as a margin in the shallower water around the deeper potholes, or may grow completely across some of the shallower areas. Some potholes are practically bare, owing to the removal of vegetation by grazing, burning, plowing, or other factors; in these cases, revegetation is rapid once the disturbance is removed.

Twenty-eight species commonly found in the prairie pothole region are listed here, in groups corresponding roughly to their tolerance to deep water. All the emergent species are tolerant to prolonged periods of drying out, and some may maintain themselves for years on unflooded soil, giving way to dryland species only under the pressure of competition.

Submerged and floating plants found in the deepest water:

- Pondweeds (*Potamogeton* spp.)
- Wildcelery (*Vallisneria americana*)
- Duckweeds (*Lemna* spp.)
- Coontail (*Ceratophyllum demersum*)
- Buttercups (*Ranunculus* spp.)
- Water milfoils (*Myriophyllum* spp.)
- Bladderworts (*Utricularia* spp.)

Deep-water emergents:

- Cattail (*Typha latifolia*)
- Whitetop (*Scolochloa festucacea*)
- Softstem bulrush (*Scirpus validus*)
- Hardstem bulrush (*S. acutus*)
- Sedges (*Carex* spp.)

Shallow-water emergents:

- Burreeds (*Sparganium* spp.)
- Arrowheads (*Sagittaria* spp.)
- Water plantain (*Alisma plantago-aquatica*)
- Mannagrass (*Glyceria grandis*)
- Reed (*Phragmites communis*)
- Slough grass (*Beckmannia syzigachne*)
- Spikerush (*Eleochairis palustris*)
- River bulrush (*Scirpus fluviatilis*)
- Alkali bulrush (*S. paludosus*)
- Smartweeds (*Polygonum* spp.)
- Water parsnip (*Sium suave*)

Plants of intermittently flooded shorelines:

- Wild barley (*Hordeum jubatum*)
- Bluejoints (*Calamagrostis* spp.)

Table 1. - Average expenditures by fishermen in the Missouri River Basin

Transportation: determined by applying a rate of 7 cents to the average number of miles traveled per day by each person; the average number of miles per person per day was determined by dividing the round-trip mileage by the number of persons in the party and the number of days in the trip.
Trip: includes expenditures for food, lodging, refreshments, fees for guides or entrance to areas, rentals of horses, boats, bait, miscellaneous items, etc.
Investment: consists of cost of equipment used in pursuit of a sport, which is prorated according to the life expectancy and the number of days used each year.
Annual: consists of recurring expenses, such as license fees, hunting and fishing magazine subscriptions, club dues, and contributions to conservation causes, which are prorated on the basis of the total number of days that the individual fished during the year of study.

Location and year of study	Expenditure per fishing day					Expenditure per pound of fish	Estimated utilization (number of fishermen days)	Estimated expenditures by all fishermen	Estimated expenditures by all fishermen per acre of lake surface	Estimated expenditures by all fishermen per mile of stream
	Transportation	Trip	Investment	Annual	Total					
WARM-WATER FISHING										
Wyoming [2, 3], Ocean Lake (6,100 acres):										
1947 Summer	$4.86	$2.85	1/$1.12	1/$0.43	$ 9.26	$ 0.95	7,639	$ 70,737.14	$ 11.60	---
1947 Winter	6.20	3.83	1/1.12	1/.43	11.58	1.19	794	9,194.52	1.51	---
1948 Summer	4.62	2.85	1/1.12	1/.43	9.02	1.50	15,814	142,642.28	23.38	---
1948 Winter	6.20	3.83	1/1.12	1/.43	2/11.58	1.92	441	5,106.78	.84	---
Nebraska [4, 5], Lake Maloney (1,670 acres):										
1948	---	---	---	---	2/2.42	1.09	18,000	43,560.00	26.08	---
1949	1.41	.47	1/.45	1/.09	2.42	1.50	15,259	36,926.78	22.11	---
Montana [10], Fort Peck Reservoir (245,000 acres) and Missouri River below Fort Peck Dam (12 miles):										
1948	1.47	.74	1/.69	1/.23	3/3.13	2.05	15,450	48,358.50	.20	---
						1.33	9,600	30,048.00	---	$ 2,504.00
1949	1.61	.99	1/.38	1/.08	3/3.06	2.25	16,300	49,878.00	.20	---
						1.47	5,750	17,595.00	---	1,466.25
1950	1.40	.35	4/.65	4/.35	3/2.75	1.38	20,380	56,045.00	.23	---
						2.29	5,790	15,922.50	---	1,326.87
Nebraska and Kansas [19], Republican River (43 miles):										
1951	1.09	.17	5/.45	5/.09	1.80	2.41	17,426	31,366.80	---	729.46
Montana [20], Split Rock Lakes (120 acres):										
1951	2.71	.70	6/2.05	6/.45	3/5.91	4.12	516	3,049.56	25.41	---
South Dakota [13], Angostura Reservoir (5,600 acres):										
1952	2.66	.64	7/1.50		4.80	2.19	41,018	196,886.40	35.16	---
South Dakota [14], Cottonwood Lake (1,450 acres):										
1952	1.58	.21	7/1.00		2.79	1.04	16,495	46,021.05	31.74	---
Nebraska [18], Harry Strunk Lake (1,768 acres):										
1952	2.05	8/.87	5/.45	5/.09	3.16	1.69	55,000	173,800.00	98.30	---
Medicine Creek below Harry Strunk Lake (1 3/4 miles):										
1951	---	---	---	---	9/3.16	.79	5,000	15,800.00	---	9,028.57
WEIGHTED AVERAGE	---	---	---	---	3.72	1.54	---	---	10/29.74	11/1,329.08
Montana, Warm-water fishermen [8] 12/:										
Yellowstone County - predominantly cold water, 1949	---	---	.91	.38	---	---	---	---	---	---
Valley and Roosevelt Counties - predominantly warm water, 1949	---	---	.65	.35	---	---	---	---	---	---
COLD-WATER FISHING										
South Dakota [6, 10], Deerfield Reservoir (435 acres):										
1949	---	---	---	---	2/5.20	2.99	6,730	39,944.00	80.33	---
1950	2.60	1.31	1/1.20	1/.09	5.20	4.43	8,190	42,588.00	97.90	---
Montana [7, 15], West Gallatin River, Upper Section (55 miles):										
1949	---	---	---	---	13/4.48	4.48	15,000	67,200.00	---	1,221.82
West Gallatin River, Middle Section (28 miles):										
1949	1.67	.31	1/2.11	1/.39	4.48	4.83	11,100	49,728.00	---	1,776.00
1950	1.67	.31	1/2.11	1/.39	4.48	5.19	13,100	58,688.00	---	2,096.00
Wyoming [11], Pathfinder Reservoir (22,600 acres):										
1951	3.39	1.33	6/2.05	6/.45	7.22	3.94	7,850	56,677.00	2.51	---
Alcova Reservoir (2,500 acres):										
1951	2.49	.80	6/2.05	6/.45	5.79	5.39	4,750	27,502.50	11.00	---
Fremont Canyon, North Platte River between Pathfinder and Alcova Reservoirs (4 miles):										
1951	3.40	.59	6/2.05	6/.45	6.49	4.61	1,350	8,761.50	---	2,190.38
Montana [20], North Fork Sun River above Gibson Reservoir (50 miles):										
1951	2.87	5.33	6/2.05	6/.45	10.70	8.59	668	7,147.60	---	142.95
Gibson Reservoir (1,360 acres):										
1951	2.18	1.89	6/2.05	6/.45	6.57	4.16	895	5,880.15	4.32	---
North Fork Sun River between Gibson and Diversion Reservoirs (8 miles):										
1951	2.71	.70	6/2.05	6/.45	3/5.91	11.13	2,020	11,938.20	---	1,492.28
Diversion Reservoir (100 acres):										
1951	2.71	.70	6/2.05	6/.45	3/5.91	7.33	2,328	13,758.48	137.58	---
North Fork Sun River below Diversion Reservoir (22 miles):										
1951	2.71	.70	6/2.05	6/.45	3/5.91	5.05	1,290	7,623.90	---	346.54
Pishkun Canal (12 miles):										
1951	2.71	.70	6/2.05	6/.45	3/5.91	12.16	179	1,057.89	---	88.16
Pishkun Reservoir (1,550 acres):										
1951	2.71	.70	6/2.05	6/.45	3/5.91	12.26	1,575	9,308.25	6.01	---
Willow Creek Reservoir (1,400 acres):										
1951	2.71	.70	6/2.05	6/.45	3/5.91	4.42	202	1,193.82	.85	---
Tunnel Lake (20 acres):										
1951	2.71	.70	6/2.05	6/.45	3/5.91	9.96	504	2,978.64	99.29	---
Wood Lake (20 acres):										
1951	3.21	.43	6/2.05	6/.45	6.14	14/11.88	385	2,363.90	118.20	---
Montana [21], Madison River below Madison Reservoir (33 miles):										
1950	3.55	1.85	6/2.05	6/.45	3/7.90	3.31	8,107	64,045.30	---	1,940.77
Madison Reservoir (3,800 acres):										
1950	3.55	1.85	6/2.05	6/.45	3/7.90	3.47	7,972	62,978.80	16.57	---
Madison River above Madison Reservoir (34 miles):										
1951	2.94	2.51	6/2.05	6/.45	7.95	3.39	7,307	58,090.65	---	1,708.55
Madison River below Hebgen Reservoir (31 miles):										
1952	6.83	3.75	6/2.05	6/.45	3/13.08	7.97	7,246	94,777.68	---	3,057.34
Hebgen Reservoir (10,140 acres):										
1952	6.83	3.75	6/2.05	6/.45	3/13.08	8.21	10,140	132,631.20	9.90	---
Wyoming [17], North Platte River (5 1/2 miles):										
1952	4.34	8.43	15/2.68		15.45	9.98	6,847	105,786.15	---	19,233.84
WEIGHTED AVERAGE	---	---	---	---	7.38	5.13	---	---	8.25	1,830.31
Montana, Cold-water fishing [8] 12/:										
Yellowstone County - predominantly cold water, 1949	---	---	2.20	.48	---	---	---	---	---	---
Valley and Roosevelt Counties - predominantly warm water, 1949	---	---	1.62	.32	---	---	---	---	---	---

1/ Data obtained in the field.
2/ Applied from the total daily expenditure obtained either in the preceding or succeeding year.
3/ One basic figure obtained from study area as a whole and applied to separate segments.
4/ Rounded and adjusted investment or annual expenditure applied from Valley and Roosevelt Counties, Mont. [8].
5/ Applied from Lake Maloney, Nebr. [4].
6/ Rounded and adjusted investment or annual expenditure applied from Yellowstone County, Mont. [8].
7/ Judgment estimate of total of investment and annual expenditures based on several studies.
8/ Determined from survey of local businesses.
9/ Applied from Harry Strunk Lake.
10/ Fort Peck Reservoir excluded for the purpose of determining this figure because relatively little of the surface acreage of Fort Peck Reservoir was fished, and, therefore, the values of 20 to 23 cents per acre for Fort Peck Reservoir are wholly unreasonable.
11/ Tailwater fisheries below Fort Peck Reservoir and Harry Strunk Lake are not comparable to the Republican River, therefore, this figure has no real meaning.
12/ Figures shown here have been modified from those for the average license holder to those for the average fisherman in the field.
13/ Applied from Middle Section, West Gallatin River. Not included in weighted average expenditure figure because expenditures were artibrarily estimated from data secured in the Middle Section.
14/ Based on yield from 2-week period; however, this period is thought to represent most of the fishing.
15/ Adjusted, but unrounded, total of investment and annual expenditures applied from Yellowstone County, Mont. [8].

BHL

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Plants of intermittently flooded shorelines--Continued

Reed canarygrass (<u>Phalaris arundinacea</u>)
Willows (<u>Salix</u> spp.)

These waters contain, in addition to the higher plant species, abundant blue-green and green algae, as well as animal life, mainly in the form of invertebrates such as snails, insects, and crustaceans.

In general the tendency is for plants to become arranged in zones. The species most tolerant to deep water occur in the center with species less tolerant to water arranged in rings about the border as the water decreases in depth.

When undisturbed by grazing or cultivation, potholes tend to develop a cover of sedge or whitetop as shown in figure 4. These species are tolerant of a wide range of conditions and are able to crowd out other emergents. In areas of high permanence, which do not commonly go dry, these species form a ring around the margin as shown in the illustration. Areas of low permanence may become completely overgrown with pure stands of these species.

Both whitetop and the large sedges are highly palatable to livestock and are often grazed to the point where other species such as cattail or hardstem bulrush become dominant. Figure 5 shows a pothole, mainly in pasture, where cattail is predominant.

Plowing, with nearly complete removal of the vegetation, starts a new succession. Upon reflooding, a complex stand of vegetation may develop and persist for some years. Figure 6 shows an area of medium permanence which originally had a cover of sedge and whitetop. During the drought of the 1930's, the large center portion was plowed. Upon reflooding, a dense stand of mixed vegetation, mainly hardstem bulrush, developed. Subsequent intermittent grazing of the north end produced even more complexities of the vegetation there.

Figure 7 shows a medium-permanence area which in 1949 was open water surrounded by a margin of mixed sedge and whitetop. In 1950, when the cover map was made, water levels had dropped and the area had gone dry, apparently stimulating the growth of a new crop of emergents, some of them shallow-water species. In 1951, with rising water levels, the cover at the center became less dense, and in 1952, with a further rise in levels, it had all but disappeared. Such changes in the amount of vegetation may be widespread and may cause great variation in the number of open-water areas in the region.

Further variations in vegetation may be due to differences in water chemistry. This is discussed by Moyle (1945) and Metcalf (1931). The vegetation of potholes on the study area itself did not appear to be strongly influenced by variations in water chemistry. However, there were several potholes within a few miles that were so alkaline as to be practically barren.

The density of the vegetation is a highly variable factor, and most species tend to become sparse as the water in which they grow increases in depth. They increase in density again as the water recedes.

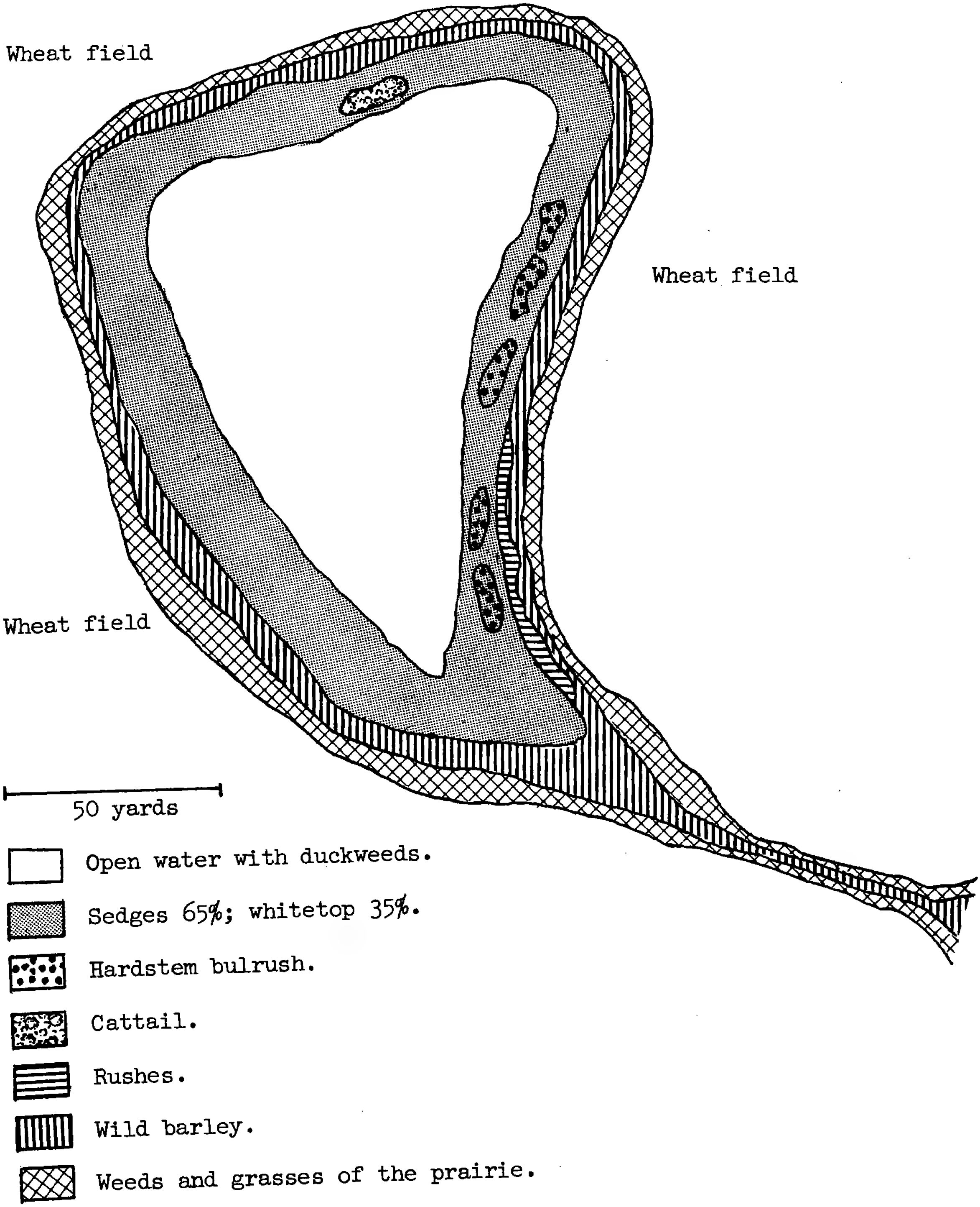

Figure 4.--COVER MAP OF A SEDGE-WHITETOP POTHOLE, WAUBAY STUDY AREA.

Table 2. - Average expenditures by hunters in the Missouri River Basin

Transportation: determined by applying a rate of 7 cents to the average number of miles traveled per day by each person; the average number of miles per person per day was determined by dividing the round-trip mileage by the number of persons in the party and the number of days in the trip.
Trip: includes expenditures for food, lodging, refreshments, fees for guides or entrance to areas, rentals of horses, boats, ammunition, miscellaneous items, etc.
Investment: consists of cost of equipment used in pursuit of a sport, which is prorated according to the life expectancy and the number of days used each year.
Annual: consists of recurring expenses, such as license fees, hunting and fishing magazine subscriptions, club dues, and contributions to conservation causes, which are prorated on the basis of the total number of days that the individual hunted during the year of study.

Location and year of study	Expenditure per hunting day					Expenditure per unit of game	Estimated utilization (number of hunter days)	Estimated expenditures by all hunters	Estimated expenditures by all hunters per section of land
	Transportation	Trip	Investment	Annual	Total				
PHEASANT HUNTING									
Montana, Yellowstone Unit, 65 sq. miles of irrigated land [12]:									
All hunters, 1948 1/	---	---	---	---	2/$ 3.08	$ 3.37	4,600	$ 14,168.00	$ 217.97
Nonlocal hunters, 1949	$ 2.28	$ 0.62	3/$ 0.66	3/$ 0.15	3.71	4.95	3,400	12,614.00	194.06
Rural-resident hunters, 1949	.00	.48	3/.66	3/.15	1.29	1.41	1,200	1,548.30	23.82
All hunters, 1949	1.69	.58	.66	.15	3.08	3.88	4,600	14,162.00	217.88
Wyoming, Shoshone Unit, 45 sq. miles of irrigated land [19]:									
Nonlocal hunters, 1949	---	---	---	---	2/4.04	2.42	534	2,157.36	47.94
Rural-resident hunters, 1949	---	---	---	---	2/1.42	1.24	190	269.80	6.00
All hunters, 1949	---	---	---	---	3.35	2.19	724	2,427.16	53.94
Nonlocal hunters, 1950	2.45	.74	3/.46	3/.39	4.04	2.46	640	2,585.60	57.46
Rural-resident hunters, 1950	.00	.57	3/.46	3/.39	1.42	1.24	315	447.30	9.94
All hunters, 1950	1.64	.68	.46	.39	3.18	2.15	955	3,032.90	67.40
South Dakota, Missouri River Unit, 50.3 sq. miles of bottomland and upland adjacent to Missouri River [22]:									
Nonlocal hunters, 1951	1.74	.55	4/1.00	3/.10	3.39	2.59	237	803.43	15.97
Rural-resident hunters, 1951	.00	.50	4/1.00	3/.10	1.60	1.78	81	129.60	2.58
All hunters, 1951	1.30	.53	1.00	.10	2.93	2.73	318	933.03	18.55
Nebraska, North Loup Unit, 3 areas consisting of 35 sq. miles of irrigated land; 53 sq. miles of dry bottomland; and 28 sq. miles of dry upland [24]:									
Nonlocal hunters, 1950	2.95	1.51	4/1.00	3/.12	5.58	5.75	856	4,776.48	41.18
Rural-resident hunters, 1950	.00	.56	5/.91	3/.26	1.73	2.15	421	728.33	6.28
All hunters, 1950	1.75	1.12	.96	.18	4.31	4.71	1,277	5,504.81	47.46
Nonlocal hunters, 1951	---	---	---	---	2/5.58	3.00	469	2,617.02	22.56
Rural-resident hunters, 1951	---	---	---	---	2/1.73	1.48	458	792.34	6.83
All hunters, 1951	---	---	---	---	3.68	2.42	927	3,409.36	29.39
Nebraska, Republican Unit. 2 areas consisting of 21.1 sq. miles of irrigated land and 19.3 sq. miles of dry upland [24]:									
Nonlocal hunters, 1951	2.89	.91	4/1.00	3/.12	4.92	4.35	153	752.76	18.63
Rural-resident hunters, 1951	.00	.38	5/.91	3/.09	1.38	3.02	402	554.76	13.73
All hunters, 1951	.80	.53	.93	.10	2.36	3.66	555	1,307.52	32.36
Nonlocal hunters, 1952	---	---	---	---	2/4.92	2.24	101	496.92	12.30
Rural-resident hunters, 1952	---	---	---	---	2/1.38	1.11	337	465.06	11.51
All hunters, 1952	---	---	---	---	2.36	1.48	438	961.98	23.81
WEIGHTED AVERAGE	---	---	---	---	3.19	3.21	---	---	86.16
Montana, Pheasant hunting [8] 6/:									
Yellowstone County - predominantly urban, 1949	---	---	1.08	.29	---	---	---	---	---
Valley and Roosevelt Counties - predominantly rural, 1949	---	---	.91	.33	---	---	---	---	---
DUCK HUNTING									
Montana, Yellowstone Unit, 65 sq. miles irrigated land adjacent to Yellowstone River [12]:									
All hunters, 1948 1/	---	---	---	---	2/4.32	6.22	475	2,052.00	31.57
All hunters, 1949 1/	2.31	1.37	3/.41	3/.23	4.32	6.70	1,100	4,752.00	73.08
Wyoming, Shoshone Unit, 45 sq. miles of irrigated land adjacent to Shoshone River [19]:									
Nonlocal hunters, 1949	2.60	1.07	3/.48	3/.48	4.63	3.26	164	759.32	16.87
Rural-resident hunters, 1949	.00	.76	3/.48	3/.48	1.72	1.07	23	39.56	.88
All hunters, 1949	2.28	1.03	.48	.48	4.27	2.96	187	798.88	17.75
WEIGHTED AVERAGE	---	---	---	---	4.31	5.80	---	---	43.45
Montana, Duck hunters [8] 6/:									
Yellowstone County - predominantly urban, 1949	---	---	1.33	.66	---	---	---	---	---
Valley and Roosevelt Counties - predominantly rural, 1949	---	---	1.04	.69	---	---	---	---	---
DEER HUNTING 7/									
Montana, Fort Peck Area [1]:									
Undetermined area, 1948	---	---	---	---	8/9.84	30.80	---	---	---
South Dakota, Missouri River Unit, bottomland adjacent to Missouri River [22]:									
Mobridge Area, 8.3 sq. miles, 1951	1.03	.48	9/1.00	3/3.96	6.47	30.61	123	795.81	95.88
Fielder Area, 50.0 sq. miles, 1951	1.85	.29	9/1.00	3/2.38	5.52	43.49	323	1,782.96	35.66
Gavins Point Area, 16.5 sq. miles, 1951	1.28	.42	9/1.00	3/3.43	6.13	33.53	361	2,212.93	134.12
WEIGHTED AVERAGE	1.46	.38	1.00	3.09	5.93	36.03	---	---	64.05
AVERAGE 10/	---	---	---	---	6.99	34.61	---	---	---
Montana, Deer hunters [8] 6:									
Yellowstone County - predominantly urban, 1949	---	---	1.58	.91	---	---	---	---	---
Valley and Roosevelt Counties - predominantly rural, 1949	---	---	2.84	1.81	---	---	---	---	---
ELK HUNTING 7/									
Montana, West Gallatin Area [23]:									
Undetermined area, 1954	4.64	3.00	11/4.55	11/1.15	12.19	254.23	---	---	---
Montana, Elk hunters [8] 6/:									
Yellowstone County - predominantly urban, 1949	---	---	3.84	.83	---	---	---	---	---
Valley and Roosevelt Counties - predominantly rural, 1949	---	---	5.75	1.25	---	---	---	---	---

1/ Data insufficient for individual breakdown.
2/ Applied from total daily expenditure obtained either in preceding or succeeding year.
3/ Data obtained in the field.
4/ Rounded and adjusted average of investment expenditure of pheasant hunters applied from special Montana survey [8].
5/ Adjusted investment expenditures of predominantly rural pheasant hunters applied from Valley and Roosevelt Counties, Mont. [8].
6/ Figures shown here have been modified from those for the average license holder to those for the average hunter in the field.
7/ Rural-resident and nonlocal hunters not segregated.
8/ Actually represents expenditure per hunter per trip, and since some hunters spent more than 1 day per trip, the average expenditure per day would be somewhat smaller. Data were insufficient to determine exact expenditure per day.
9/ Rounded and adjusted average investment expenditure of pheasant hunters applied from special Montana survey [8], because deer hunters along the Missouri River were required to use shotguns (see text).
10/ Simple unweighted average of Fort Peck Area and average of Missouri River Unit.
11/ Adjusted average investment and annual expenditure of elk hunters applied from special Montana survey [8].

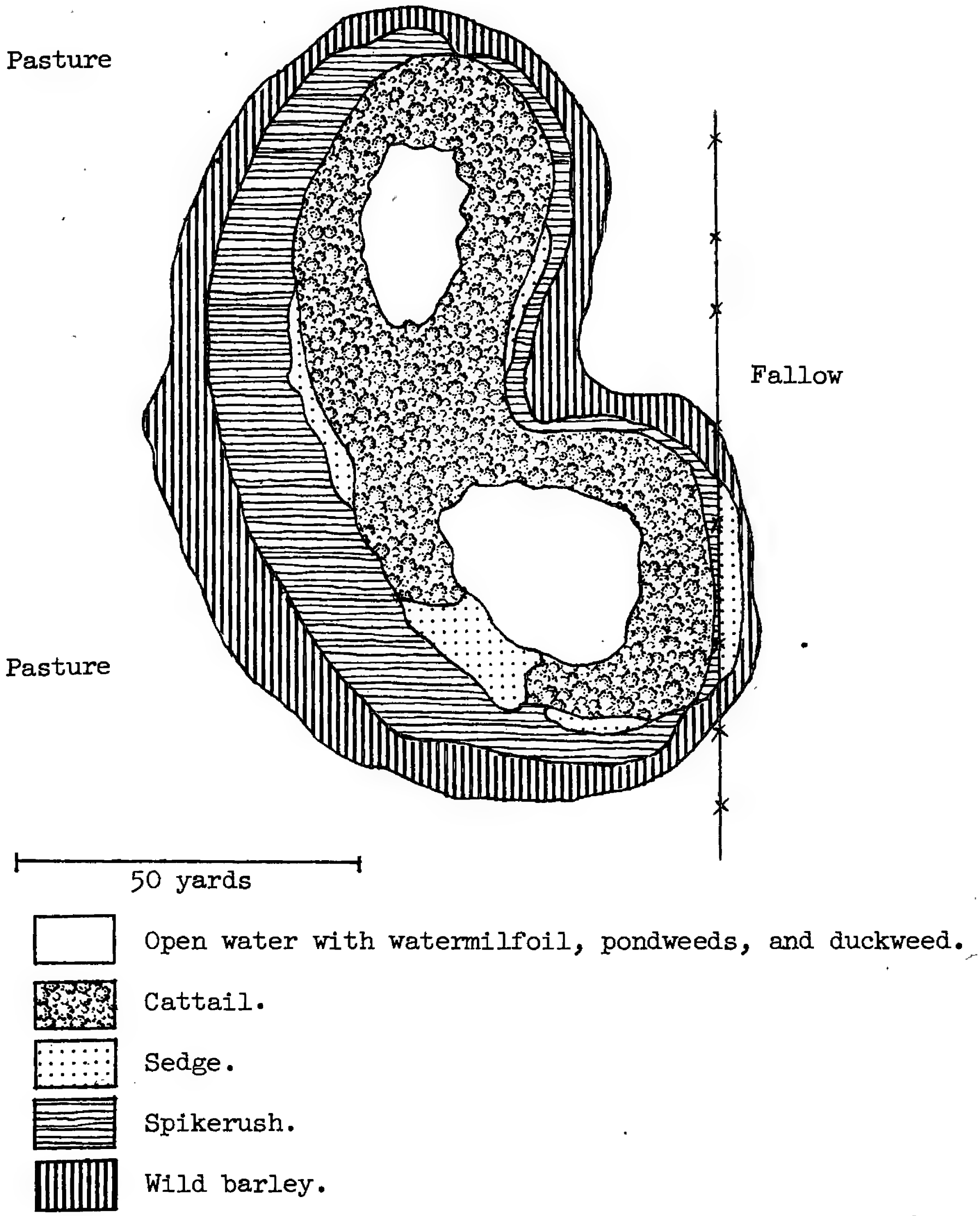

Figure 5.--COVER MAP OF A CATTAIL POTHOLE, WAUBAY STUDY AREA.

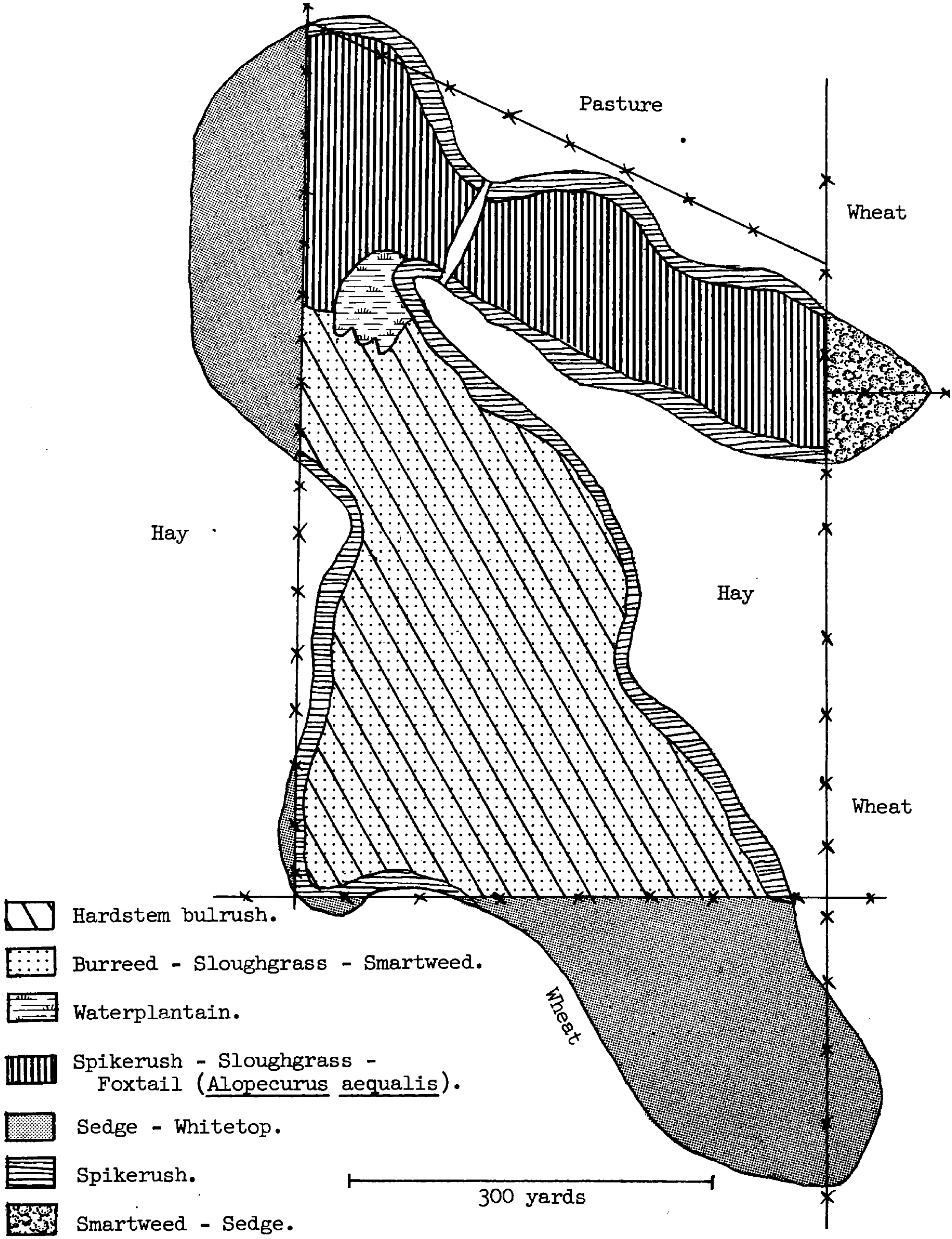

Figure 6.--COVER MAP OF A POTHOLE, WAUBAY STUDY AREA, AFTER PLOWING OF CENTER PORTION.

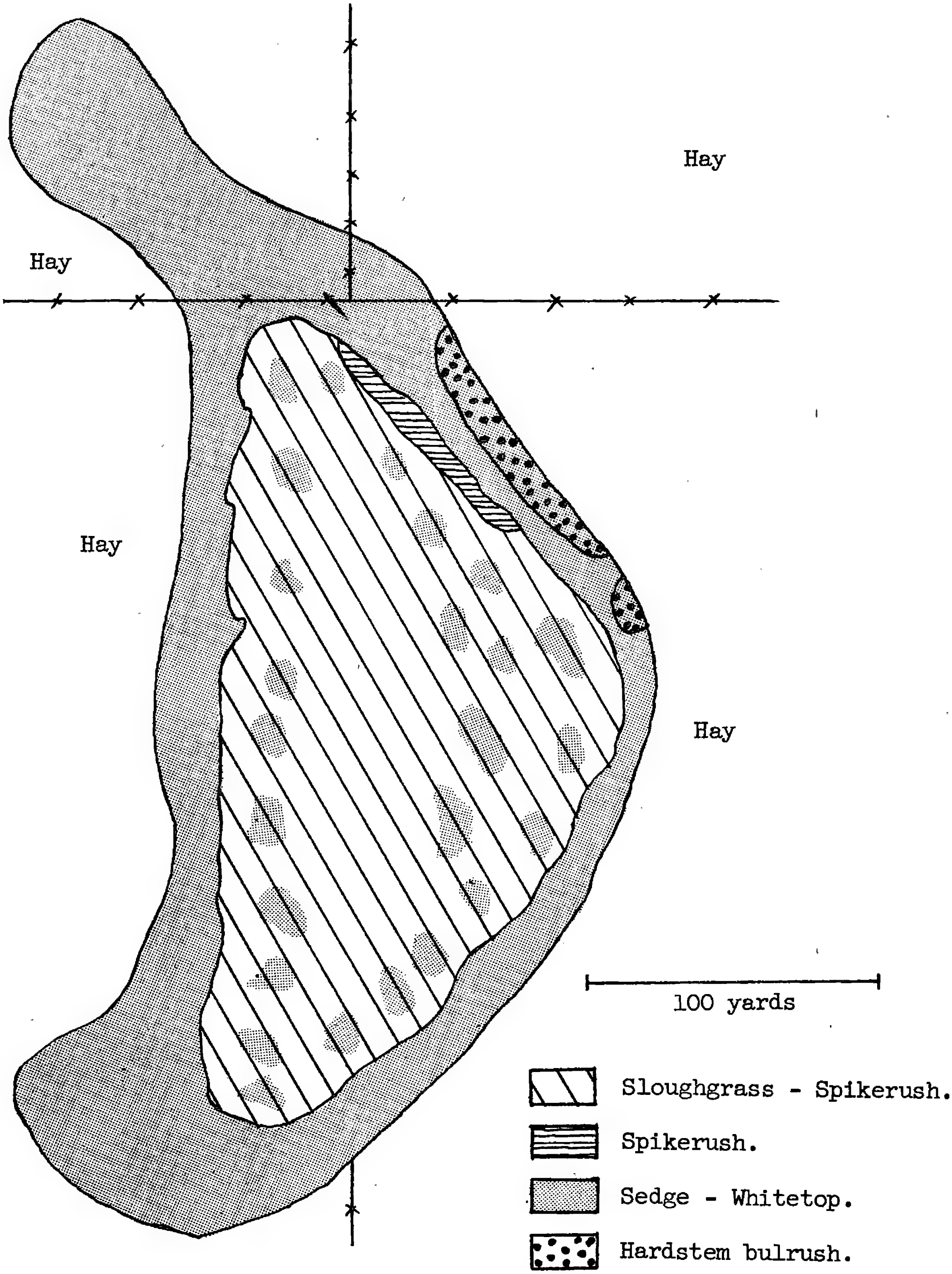

Figure 7.--COVER MAP OF A POTHOLE, WAUBAY STUDY AREA, WITH VEGETATION INFLUENCED BY FLUCTUATING WATER LEVELS.

Animal species

The following species of ducks are known to breed on the area:

Abundant:
- Blue-winged teal
- Gadwall
- Mallard
- Pintail
- Ruddy duck

Common:
- Shoveler
- Redhead
- Lesser scaup
- Canvasback

Rare:
- Baldpate
- Green-winged teal
- Cinnamon teal

Other water birds breeding on the area are horned grebes, pied-billed grebes, and an abundance of coots. One pair of Canada geese attempted unsuccessfully to nest on an island in one of the study-area potholes in 1952, and a pair was successful in bringing off a brood in the same pothole in 1953.

Numerous shorebirds and other water birds are found in and around the potholes, while most of the prairie species are found on the uplands. One bird of particular importance to ducks was the crow, which occasionally nested in woodlots and did considerable damage to duck nests.

The mammals of greatest importance to waterfowl are the muskrat, found in abundance in the potholes and serving to some extent to open up the vegetation, and the skunk, which is common in the area and is the most serious predator on duck nests. The other prairie mammals found in the region have only a minor influence on the duck population.

Land use

Farming in this area is based on the cultivation of small grains (wheat, flax, barley, and oats). Sixty-three percent of the study area is devoted to this use. Twenty-two percent of the land is less intensively used, being devoted to pasture and hay, while a very small amount is in planted woodlot (0.7 percent of the total area). The remaining 15 percent is wetland, of which a considerable amount furnishes hay, forage, and crops, particularly in dry years. During the drought years, according to local residents, the most productive land on the area was what is now considered wetland. These wet areas are now being drained with the consequent loss of this reserve should another drought occur.

The present trend is toward an increase in cultivation, although the steepness of many slopes and the deterioration of much of the land indicates that the trend should be toward less cultivation and more use of grass.

Agriculturalists agree that use as grassland would result in a higher income, even considering the small size of the farming units, which average about 320 acres (U. S. Dept. of Commerce, 1945). The main obstacles to the shift to grassland farming in this area are resistance to change, and the period of resulting lower income which would occur during the changeover period.

Limitations of rainfall and the mechanical difficulties of cultivation in this area lead to low incomes, even with present high prices and over-intensive use of the land.

Farming practices have considerable effect on the water areas themselves, not only through grazing, haying, and burning, but also through complete plowing of the bottoms of the more temporary areas.

Classification of potholes

The term "pothole" in this report refers to the depressions in glacial moraine which become filled with runoff waters from the surrounding slopes. There is no evidence that water levels are influenced in this region by a general water table. Classification of potholes on the study area has been based largely on their longevity, or the length of time they retain water each year, and is presented on the basis of the "WETLAND CLASSIFICATION (PRAIRIE POTHOLE DIVISION)" derived from Martin et al. (1953). The classes of areas are described below.

1. Seasonally flooded basins:

 1a. Intermittent areas: Shallow depressions that contain standing water for only a few days in a wet spring or after heavy rains and are generally not more than 20 inches deep at any time. They will never hold water through June 1, and in many years they will be dry throughout the season. Very few of these areas have an effect on crop production except to retard seeding in years of heavy runoff. Upland plants are abundant, and scattered wetland plants include smartweeds, sedges, spikerush, whitetop, burreeds, and water plantain. However, these areas may be plowed or grazed to the extent that no wetland vegetation is visible.

 1b. Temporary marshes: Shallow depressions that usually contain water for a few weeks in the spring and after heavy rains. They may hold water through June and into July in years of heavy runoff. They may hold up to 24 inches of water in the spring of such a year, or may be completely dry after an open winter. These areas are all capable of bearing such species as smartweeds, sedges, spikerush, slough grass, mannagrass, whitetop, water plantain, and burreeds, unless the vegetation is removed by cultivation or grazing. In dry or moderately wet years crops may be raised in these areas. In wet years they are flooded too long for cultivation.

3. Shallow marshes: In a wet year will commonly contain up to 30 inches of water in the spring and will hold water through July. A few areas hold no water in years with below-normal precipitation. All are too wet to cultivate in years with near-normal runoff. Vegetation includes the species listed under 1b and hardstem bulrush, softstem bulrush, and cattail. Grazing may remove most of the vegetation as these areas dry out during the summer, but if undisturbed the vegetation is complete and dense.

4. Deep marshes: Contain up to 4 feet of water in a wet spring and often hold water all year. In dry years, almost all have some water in the spring, but most go dry sometime during the summer. Most of these areas are overgrown with the emergents listed previously, but a few have open water during periods of high water levels. Cover is generally sparser than that found in the shallow marshes, but varies with water levels.

5. Open water: Contain up to 5 feet or more of water in a wet spring and hold at least 3 feet without overflowing either overland or into a permeable underground channel. These areas may have a ring of marginal vegetation, or the shores may be grazed bare. If marginal vegetation is present, it is generally a narrower band than is found on such of the class 4 areas as may be temporarily open. Submerged plants and duckweeds are abundant.

It is evident from these descriptions that the classes are not well defined and that it would be possible in different years to place almost any water area in more than one class. In addition, there is continuous gradation between types of areas, and even after extensive study it is often impossible to place one in the proper class. Even local residents who have watched a pothole for a number of years cannot be relied on for an accurate estimate of its longevity. In relying heavily on the density of plant cover in classifying the potholes, weight was given to long-term average water levels as they have influenced the vegetation. It should be emphasized that "open water" refers only to areas that are open because they are too deep to support vegetation. Areas open only because of disturbance belong in one of the other four classes.

All potholes on the study area contained relatively fresh water, although a few areas of high alkalinity occur in the region. Only two areas were influenced to any extent by trees. These were both small (0.02 and 0.4 acre).

Table 3 shows the size and frequency distribution of the potholes on the Waubay study area arranged according to these classes. Size refers to all of the area within the outer margin of moist-soil vegetation. For an area where the vegetation has been removed, the size includes all of the area where the soil has been modified by water.

Even a casual inspection of table 3, as summarized in the lower portion, indicates that there is a close correlation between the size of a pothole and the permanence inferred by its position in the wetland classification. Thus,

Table 3.--Distribution of potholes, by size and by type, Waubay study area

Size class (acres)	Type 1a		Type 1b		Type 3		Type 4		Type 5		All types	
	Number	Total area	Number	Total area	Number	Total area	Number	Total area	Number	Total area	Number	Total area
0.0- 0.09	16	0.8	19	0.9	2	0.1	1	0.1	...	.....	38	1.9
0.1- 0.3	39	7.2	47	10.1	25	5.2	4	1.0	...	.....	115	23.5
0.4- 0.9	11	7.4	29	16.8	34	20.3	9	7.5	1	0.5	84	52.5
1.0- 1.9	3	3.8	7	9.7	27	33.5	16	24.6	1	1.1	54	72.7
2.0- 4.9	1	3.6	1	2.6	7	19.4	32	102.2	8	26.9	49	154.7
5.0-11.9	..	....	..	....	..	....	19	151.4	12	106.8	31	258.2
12+	..	....	..	....	1	12.4	8	172.9	11	306.8	20	492.1
All sizes	70	22.8	103	40.1	96	90.0	89	459.7	33	442.1	391	1,055.6

	Type 1a	Type 1b	Type 3	Type 4	Type 5	All types
Average size of potholes (acres)	0.3	0.4	0.9	5.2	13.4	2.7
Average number per square mile	6.2	9.2	8.5	7.9	2.9	34.7
Average acreage per square mile	2.2	3.6	8.1	40.9	39.3	94.1
Percentage of total number	17.9	26.4	24.6	22.7	8.4	100.0
Percentage of total acreage	2.2	3.8	8.6	43.6	41.8	100.0

By types:

Of type 1a areas: 78 percent are 0.0 to 0.3 acres.
Of type 1b areas: 74 percent are 0.1 to 0.9 acres.
Of type 3 areas: 64 percent are 0.4 to 1.9 acres.
Of type 4 areas: 57 percent are 2.0 to 11.9 acres.
Of type 5 areas: 70 percent are 5.0 or more acres.

By size:

Of 0.0- 0.09 acre areas: 92 percent are types 1a and 1b.
Of 0.1- 0.3 acre areas: 75 percent are types 1a and 1b.
Of 0.4- 0.9 acre areas: 74 percent are types 1b and 3.
Of 1.0- 1.9 acre areas: 80 percent are types 3 and 4.
Of 2.0- 4.9 acre areas: 65 percent are type 4.
Of 5.0-11.9 acre areas: 100 percent are types 4 and 5.
Of 12+ acre areas: 95 percent are types 4 and 5.

intermittent areas are nearly all small; open-water areas are generally large; and there is a general trend from intermittent to open water with an increase in size. If all potholes that have had their size reduced through division by road grades, or their permanence decreased by drainage, were omitted, the correlation between size and permanence among the remainder would be even closer than is indicated by table 3. Seasonal variations in water depths in different wetland classes are shown in figure 8.

Since size, depth, permanence, and density of plant cover are all closely correlated, and since there were too few potholes on the study area to permit treatment of each factor separately, most of the data concerning waterfowl use will be presented on the basis of pothole size.

Table 3 excludes 39 completely drained areas but includes 24 potholes, with an aggregate area of 89.5 acres, that have been affected to some extent by drainage. Most of this partial drainage was done before 1945, and either has been later reduced in effectiveness or was never intended to be complete, having been done to protect road grades or to prevent extensive flooding of fields. Four of the areas so affected are still open water, and five are still deep marshes. In all but three cases, drainage since 1945 has been complete and the potholes are no longer capable of holding water. Thus, 63 potholes totaling 117.5 acres have been at least affected by drainage. There is no tile drainage presently functioning on the study area, all drainage being accomplished by relatively short open ditches that lead the water into lower-lying potholes. This is typical of drainage in many types of pothole country.

A description of the water areas in this region would not be complete without a discussion of their variability. Figures 9 and 10 show the number of potholes in each wetland type which held water during the four seasons of study. This number is cumulative, and the top of the band denotes the total number of all classes that held water. These data are based on the 270 potholes (69% of total) for which complete records for the four years are available. The percentage of these 270 that held water was applied to the total number of 391 potholes. Although minor fluctuations are masked and the extremes of fluctuation are dampened because the points on the curve represent averages for the period of each coverage, these graphs give an excellent picture of general trends.

There is a tremendous difference in the surface-water picture between spring and fall on the study area. This is largely dependent on the type of season and on sudden showers which may relieve a dry spell in a matter of hours, refilling nearly all water areas. This occurred in early June of 1951. In 1950, precipitation during the growing season was about average, while 1951 and 1953 were wet in June and July. The growing season of 1952, with the exception of June, was extremely dry. These differences are reflected in the rate of decrease in the number of water areas. For instance, in early July of 1953, there were nearly twice as many potholes containing water as there were during the same period in 1950. Further differences may be noted between the years in the number of potholes at the outset of the season. This determines, to a large extent, the condition of the habitat during the waterfowl nesting season. On May 10, 1950, about 275 potholes

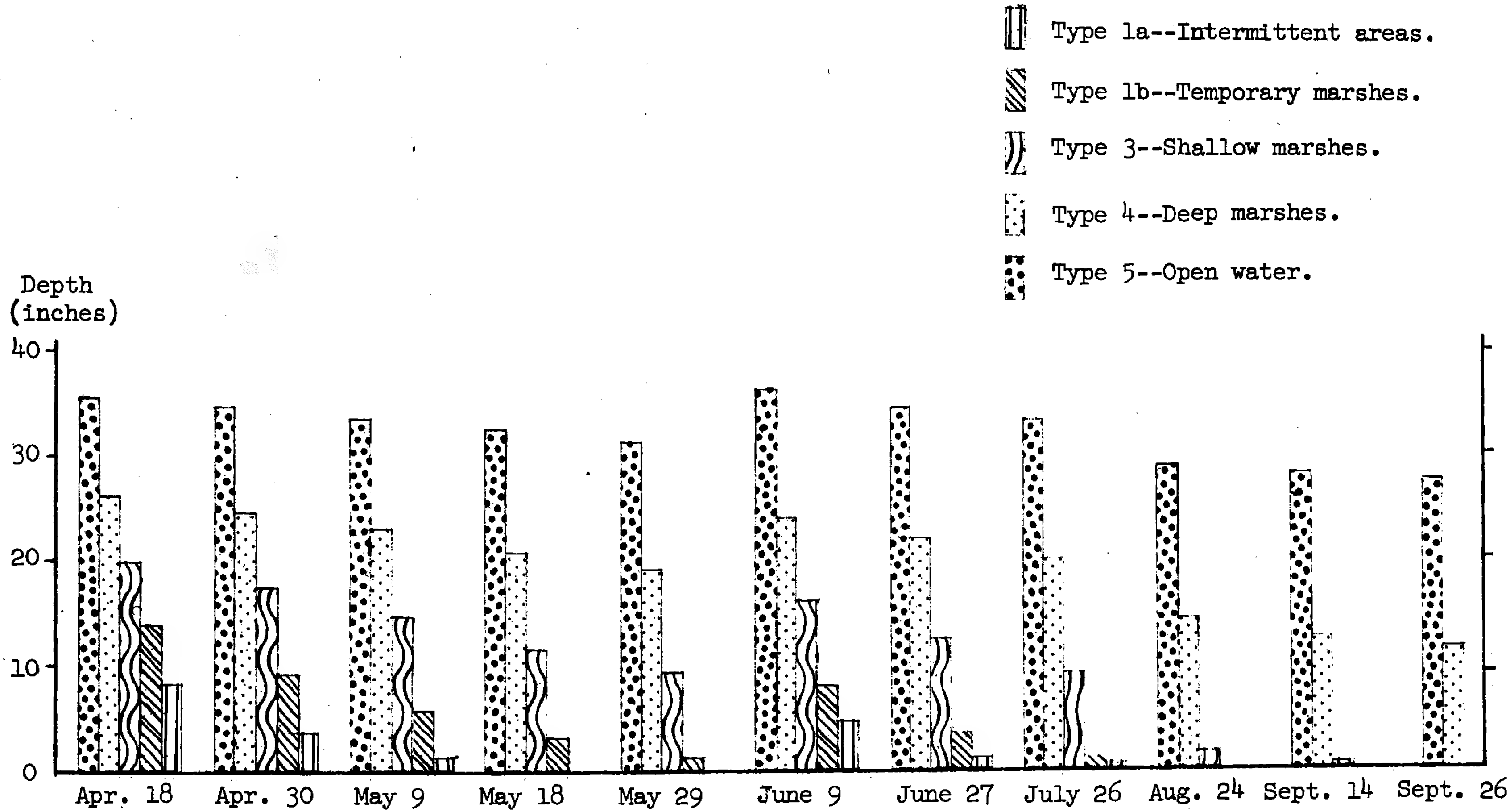

Figure 8.--AVERAGE DEPTHS OF FIVE TYPES OF POTHOLES, WAUBAY STUDY AREA, 1951.

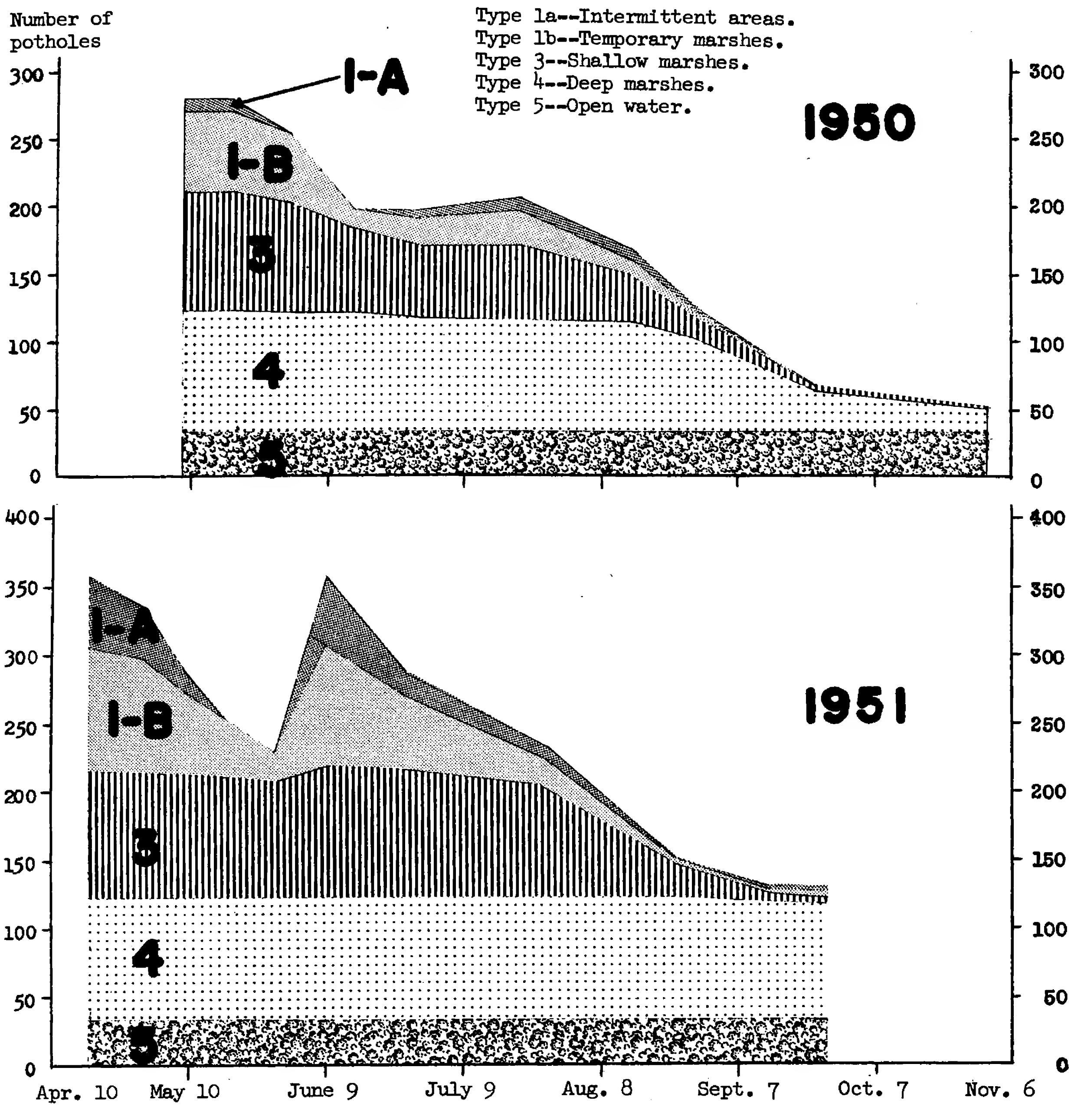

Figure 9.--VARIATION IN NUMBER OF POTHOLES WITH WATER, WAUBAY STUDY AREA, BY PERIODS, 1950 AND 1951

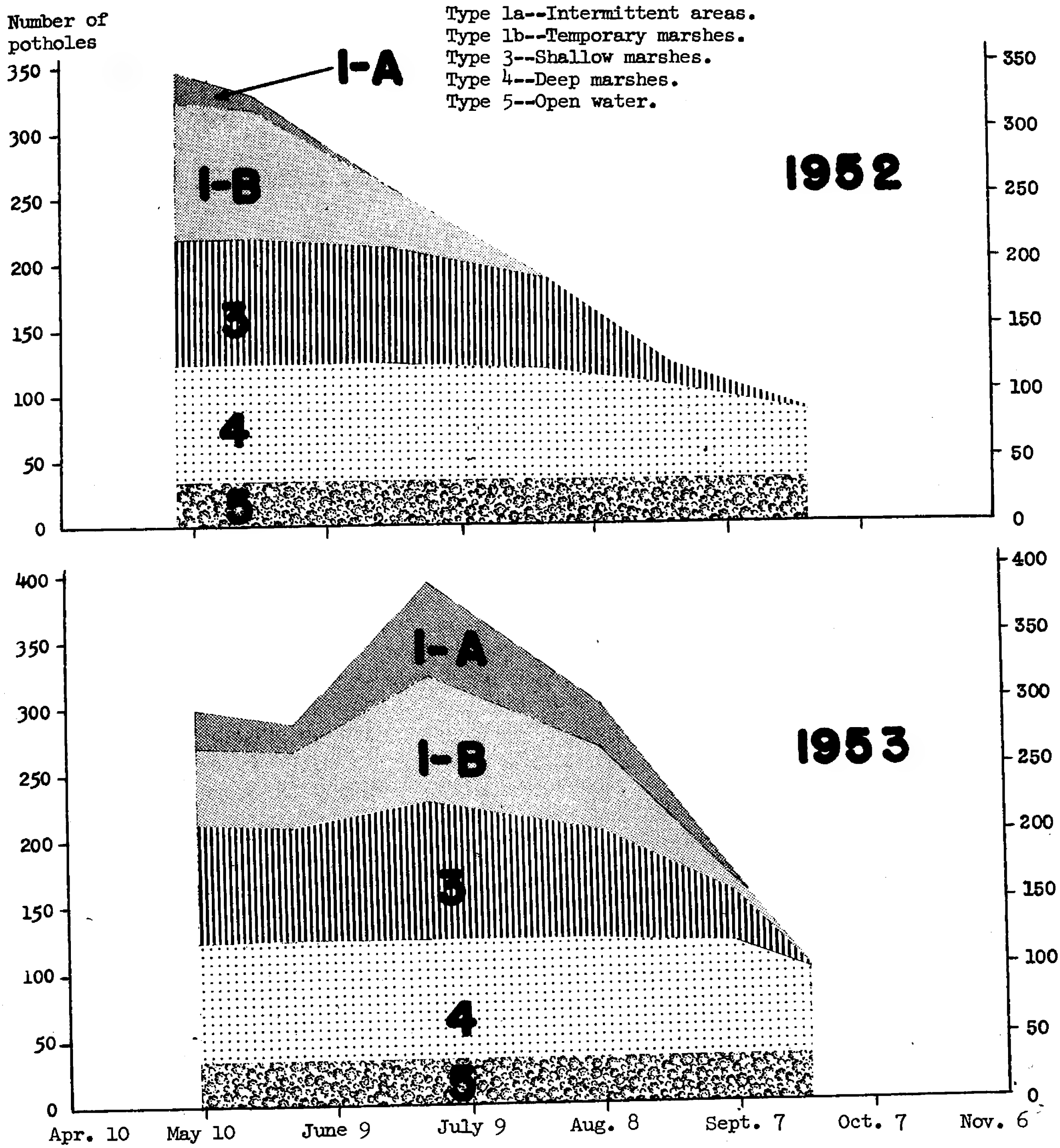

Figure 10.--VARIATION IN NUMBER OF POTHOLES WITH WATER, WAUBAY STUDY AREA, BY PERIODS, 1952 AND 1953

contained water, while on the same date in 1952, owing to heavy February snows and rapid spring runoff there were nearly 350. These conditions are briefly expressed for the four years of study in table 4. It should be noted that pothole depths followed this same general trend for the four years of the study.

Table 4.--Relative abundance of potholes on Waubay study area, 1950-53

Year	Growing season precipitation	Pothole abundance		
		before June 1	after June 1	average
1950	average	medium	fewest	fewest
1951	high	fewest	medium	medium
1952	low	most	medium	medium
1953	very high	medium	most	most

Much of this variability is due to factors not related to the actual amount of precipitation. It is dependent to a large extent on the character of the spring runoff, which is highest when the breakup comes quickly and the ground is frozen so that none of the water penetrates the soil. Under these conditions, even a moderate snowfall will put considerable amounts of water in the potholes. If this is followed by average rainfall throughout the season in the form of fairly hard showers, good supply of surface water is assured.

Forty-one potholes on the study area went dry only one year out of the three and may be used to illustrate the variability of runoff. It would be expected that all of these would have gone dry in 1950 when average water levels were their lowest. However, only 26 of the 41 went dry that year, while the remaining 15 went dry only in 1952, a much wetter year on the average. Moreover, six of the areas that went dry only in 1952 lie immediately adjacent to potholes that went dry only in 1950, indicating that local differences in weather could not be a factor. The differences are due to the character of the individual watersheds as they influence runoff from rain or from melting of drifted snow.

None of the potholes on the study area are permanent enough to survive a prolonged drought. For example, during the drought of the thirties every pothole on the study area went dry and most, even some of the most permanent, were capable of bearing crops.

DUCK POPULATIONS

Spring migrants

Early trips in 1951 and 1952 indicated that spring migrants do not use this area to any great extent. The spring breakup in this relatively high country is somewhat later than in the Minnesota and James River Valleys which are major spring-migration channels. The majority of the birds seen on the study area, even in early April, were in scattered pairs and appeared to be settled down preparing to nest. The exceptions were provided by a few scattered groups rarely amounting to more than 100 individuals. During the four years of the study, local breeding populations apparently branched from the main routes

of migration to settle down directly onto the area, while relatively few other birds passed through it.

Nesting population

A few early mallards and pintails arrived on the Waubay area in late March or early April when the first open water appeared. They usually preceded the main flight by 2 or 3 weeks. Figure 11 shows the movement of "indicated breeding pairs" (pairs, lone males, and lone females) onto the area in the spring of 1951 when the area was censused most frequently. Main breeding populations of blue-winged teal and gadwall arrived considerably later than the first arrivals, while mallards and pintails, with the exception of a few very early pioneers, arrived more or less in a body. The pattern of arrival was much the same in the other three years.

The size and species composition of the breeding population are shown in table 5. The first four columns, under "Peak date," represent the time the greatest breeding population of each species was measured. However, since the peak date represents the center of a plateau when the population was relatively stable (fig. 11), these dates are of only limited value for comparing years. The next four columns show the population of each species, in terms of indicated pairs per square mile, when each was at its height during each of the four years. In no year did all species reach their peaks on the same date. However, the total is a measure of the entire breeding potential of the spring population. The trend in breeding populations of most species was upward through 1952. The 1953 population decreased from that of 1951 and 1952, but still was higher than in 1950. The last two columns show the average populations and the species composition for the 4 years. The blue-winged teal was by far the most abundant duck while the four most important species made up almost 86 percent of the breeding population.

When each species was at its peak nesting population, few individuals were tallied as nonbreeders. Table 6, showing the blue-winged teal population in 1951, indicates the relation between breeders and nonbreeders.

At the time most of the breeding blue-winged teal had arrived (May 4 to May 22), few were nesting and most were seen as pairs, with a few migrants and courting parties still in evidence. Two to three weeks later (May 23 to June 3), nesting was well underway, and more than half of the pairs were represented by lone males, grouped males still being scarce. About 3 weeks later (June 14 to July 9), there was an increase in grouped males that had deserted their hens, then in the last stages of incubation. In the case of the blue-winged teal, where the drakes stayed with their hens until nearly hatching time, this increase in grouped males coincided with the appearance of broods. In other species, such as the mallard and pintail, whose drakes deserted their hens soon after incubation started, grouped drakes were conspicuous before broods appeared. By mid-July, when the young of the year were beginning to fly and field classification of the birds was no longer feasible, they were classed as "flying". By mid-August, populations were greatly increased by early migrants from other areas.

There were few complicating factors as long as the population of each species was computed when at its peak. Only 10 grouped blue-winged teal

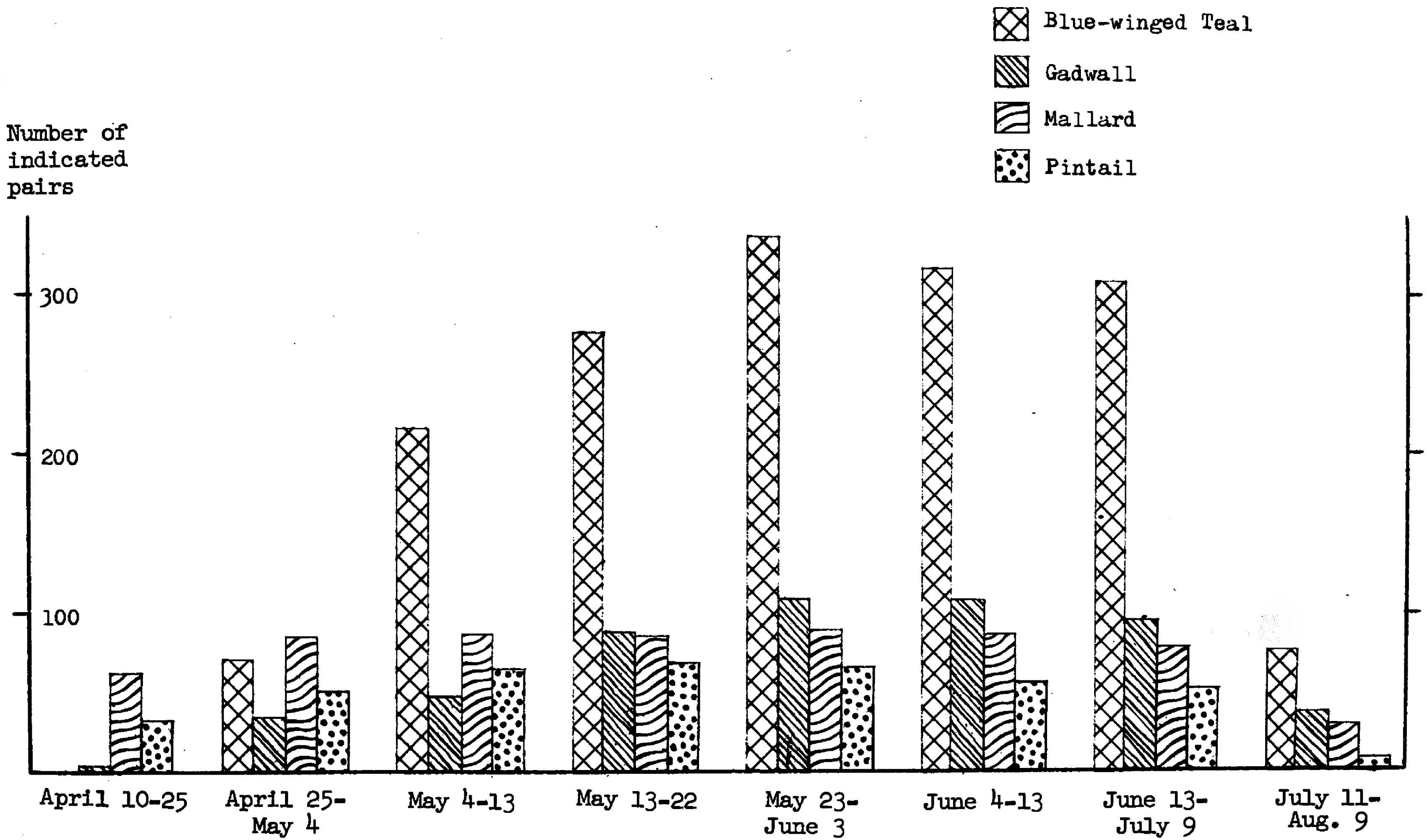

Figure 11.--BREEDING POPULATIONS OF FOUR SPECIES OF DUCKS, WAUBAY STUDY AREA, BY PERIODS, 1951

Table 5.--Breeding pair populations, spring, 1950 to 1953

Species	Peak date				Indicated pairs per square mile				Average pairs per square mile	Average percent of pairs
	1950	1951	1952	1953	1950	1951	1952	1953		
B-W teal	5/31	5/27	6/8	5/26	24.7	30.7	35.1	31.8	30.6	47.3
Gadwall	6/15	5/28	6/4	5/31	10.5	10.2	9.1	10.0	10.0	15.5
Mallard	6/15	5/7	6/15	5/13	10.0	8.5	9.2	7.2	8.7	13.4
Pintail	6/15	5/15	6/9	5/13	6.0	6.6	8.7	3.9	6.3	9.7
Shoveller	6/15	6/24	6/26	5/13	2.2	2.8	2.1	2.0	2.3	3.6
Redhead	6/29	6/8	6/13	5/27	1.9	2.2	2.1	2.1	2.1	3.2
Ruddy [1]	....	....	....	....	.4	1.5	3.7	3.6	2.3	3.6
Lesser Scaup	....	....	....	....	.7	1.1	1.0	1.2	1.0	1.6
Baldpate	....	....	....	....	.7	.4	.6	.6	.6	.9
Canvasback	....	....	....	....	.2	.5	.4	.1	.4	.6
G-W Teal	....	....	....	....	.2	.4	.4	.2	.3	.5
Wood duck	....	....	....	....	....	....	.4	.4	.1	.2
Cinnamon Teal	....	....	....	....	.1	....	....	....	trace	trace
Ringneck	....	....	....	....	....	.1	....	....	trace	trace
Unidentified	....	....	....	....	....	.2	....	....	trace	trace
Total	....	....	....	....	57.4	65.2	73.0	63.2	64.7	100.0

[1] As indicated later, ruddy-duck pairs have been underestimated. Hens of this species are shy and few are visible. Drakes are often in groups of two or more, even though the hens are nesting. Thus, the criteria used to distinguish breeding birds do not apply well in this case.

Table 6.--Composition of flying blue-winged teal population, 1951

Date	Breeding birds			Birds not actively nesting				Total indicated pairs	Total number of ducks
	Pairs	Lone males	Lone females	Grouped males	Grouped females	Brood females	Unaged [1]		
4/4	.....	.....	....	.....	....	....	......	.....	.....
4/10-4/25	.....	.....	....	.....	....	....	......	.....	.....
4/25-5/4	52	15	3	[2] 16	[2] 10	....	......	70	148
5/4-5/13	194	24	....	[2] 33	[2] 27	....	......	218	472
5/13-5/22	196	74	4	10	7	....	......	274	487
5/23-6/3	147	[3] 182	6	10	....	....	......	[4] 335	492
6/4-6/13	152	162	3	11	2	....	......	317	482
6/14-7/9	140	146	23	[5] 61	2	20	......	309	532
7/11-8/9	31	33	13	3	....	67	233	77	411
8/9-9/7	.....	.....	....	.....	....	48	1,827	.....	1,875
9/4-9/24	.....	.....	....	.....	....	3	1,300	.....	1,303

[1] Predominantly juveniles.
[2] Migrants and courting parties.
[3] Great increase in lone males indicates that many hens were nesting.
[4] Peak indicated pair populations. Only ten birds tallied as nonbreeders at this time.
[5] Grouped males becoming numerous, hatching under way.

drakes were in evidence from May 23 to June 3, 1951, the peak for this species. There was an abundance of grouped pintail drakes at this time, but records were kept separately for each species, and the peak in the pintail population occurred at an earlier date, before the drakes were so in evidence as to complicate the picture for that species. In general, other species followed the same pattern as that shown in table 6, and the chronology of the breeding season can be roughly determined from such records, provided they are sufficiently complete.

Broods

Data relating to the 1,055 broods produced on the study area from 1950 to 1953 are shown in table 7. The first four columns show the number of broods per square mile actually produced each year. There was a definite increase in production after 1950, with a slight drop in 1953. This is particularly true of the ruddy duck which rose from seventh place in 1950 to third place in 1952, with an eleven-fold increase in the number of broods produced.

The four columns under "Productivity" relate production to the spring population in terms of broods produced per 100 pairs.

The last three columns show production and productivity in terms of a 4-year average, as well as the average species composition of the broods produced. Here again, the blue-winged teal made up the bulk of the population, and the first four species made up 85 percent of the total.

There was a great deal of variability in both production and productivity among species and among years. Much of the later discussion will deal with the factors that influenced these figures. It should be remembered that since the figures for the breeding population represent a maximum and the production figures a minimum, the productivity can only be a minimum.

Fall populations

As indicated in table 6, the population by mid-August was increased by large numbers of early migrating blue-winged teal. Pintails also became abundant at this time, while other species migrated later in the season. The total number of birds on the study area was highest in late September in all four years of the study. Late-September populations for the four years are shown in table 8. Both the population size (about 2½ times the number of young raised on the area) and its species composition indicate that the majority of these birds were migrants. The number of fall migrants in the study area appeared to vary with water conditions. In 1951 and 1953, when there was abundant water throughout the Dakotas and Minnesota, few birds went through the area; in 1950 and 1952, when the surrounding low country was relatively dry, many migrants used the more permanent potholes of the study area and the surrounding upland region. The species composition of the migrants at any particular date depended, to a large extent, on the phenology of the season. In 1950, a late season, the early migrants were delayed, and the early migrating blue-winged teal and pintail made up a large percentage

Table 7.--Brood production on the Waubay study area, 1950 to 1953
[No production for wood duck, cinnamon teal, or ringneck]

	PRODUCTION (broods per square mile)[1]				PRODUCTIVITY (broods per 100 pairs)[2]				FOUR-YEAR AVERAGE		
	1950	1951	1952	1953	1950	1951	1952	1953	Broods per square mile	Productivity	Percent of broods
B-W Teal	9.6	11.9	13.7	14.0	39	39	39	44	12.3	40	52.2
Gadwall	3.2	2.6	5.1	3.5	30	25	56	35	3.6	34	15.3
Mallard	1.7	2.4	2.1	2.7	17	28	23	38	2.2	26	9.3
Pintail	1.1	2.0	2.5	1.9	18	30	29	49	1.9	32	8.1
Shoveller	.4	.4	.6	.5	18	14	29	25	.5	22	2.1
Redhead	.4	.3	1.2	.4	21	14	57	19	.6	28	2.5
Ruddy	.3	2.0	3.2	2.4	..	..	..	..	2.0	..	8.5
Lesser Scaup	.1	.3	.3	.3	..	..	..	..	.2	..	.9
Baldpate	....	....	.1	.2	..	..	..	..	.1	..	.4
Canvasback	....	.2	.3	....	..	..	..	..	.1	..	.4
G-W Teal	....	....	.2	.1	..	..	..	..	.1	..	.4
Unidentified	....	.1	....	....	..	..	..	..	trace	..	....
All species	16.6	22.2	29.2	25.8	30	34	38	40	23.6	36	100.0

[1] These figures may be multiplied by six to give a rough indication of the number of young ducks involved. Thus, there has been a 4-year average production of about 140 young ducks per square mile.

[2] Not calculated for species with a breeding-population density of less than 2 pairs per square mile, nor for the ruddy duck because of the difficulty in accurately censusing the breeding population.

Table 8.--Fall duck populations (ducks per square mile) on the Waubay study area, Sept. 15 - Oct. 1, 1950 to 1953

Species	1950		1951		1952		1953		1950-53 average	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
B-W Teal	143	26	54	18	75	15	42	22	79	20
Gadwall	71	13	22	7	66	13	7	4	42	11
Mallard	128	24	69	22	128	25	36	19	90	23
Pintail	132	24	54	18	94	18	36	19	79	20
Shoveller	15	3	11	4	11	2	11	6	12	3
Baldpate	51	9	94	30	125	24	49	26	80	21
Other	3	1	4	1	17	3	6	3	8	2
All species	543	..	308	..	516	..	187	..	389	..

of the population. In 1951, on the other hand, blue-winged teal populations were decreasing by late September, as shown in table 6.

Although the study was terminated before the hunting season in 1952 and in 1953, data for the other two years indicate that hunting rapidly drives the birds off the study area. On only one occasion was the hunting-season population known to exceed 25 percent of the preseason population, and on one occasion during the peak of migration it dropped to only 5 percent, later to rise to 36 percent of the preseason level as new migrants came in. It is not known where these birds (over 300 per square mile) go when the shooting starts, but they do not show up on the Waubay Refuge or the nearby lakes. The effect of hunting is further demonstrated by the fact that on six Fridays the population averaged 55 percent greater than on 10 weekends when hunting was heaviest. These differences were in spite of the fact that hunting pressure was extremely light, about a dozen parties of visitors on opening weekend and three or four on subsequent weekends, plus about the same number of local residents. With the exception of the opening day, shooting during the week was a rarity. This low pressure was undoubtedly due to the ban on the shooting of waterfowl by nonresidents of the State. Such hunting as was done was relatively successful, and 37 parties interviewed in 1950 and 1951 averaged 0.7 duck per man-hour of hunting effort.

Chronology of the season

Brood data provide much more accurate and useful information for studying successful nesting than does a study of either spring populations or nests. Since nearly all broods were seen and the ages of a high percentage were estimated, there was constant intensity of sampling throughout the season, and it was possible to determine quite accurately the chronology of successful nesting effort. Each brood tallied as produced on the area (Appendix I: Analysis of Production) was dated back to the start of its nest. This was done by calculating the hatching date from the estimated age of the brood, back-dating a number of days equal to the incubation period for the species, then back-dating a number of days equal to the average clutch size for the species. For instance, a brood estimated as 4 weeks old on July 15, of a species with an incubation period of 26 days and an average clutch size of 9 eggs, would have hatched June 17, begun incubation May 22, and come from a nest started May 13. Figures 12 and 13 show the chronology of successful nesting effort obtained by this method. These data refer only to successful nests, and each curve is cumulative. For example, 60 percent indicates the intensity of successful nesting effort for that period.

The year 1950 was conspicuous for retarded nesting in the blue-winged teal and gadwall, though not markedly so in the mallard and pintail. Except for the blue-winged teal, nesting in 1950 was not prolonged to a later-than-normal date, even though both the blue-winged teal and the gadwall showed an increase in the rate of nesting in late June. An unusual number of birds could be seen in mid-June of that year loafing in groups on mud flats, of drying potholes, apparently having abandoned further attempts at nesting. This was associated with a rapid drop in water levels and a decrease in number of potholes at that time. A partial recovery of water levels late in the month did not appear to result in a resumption of normal nesting effort for

the mallard and pintail. The longest nesting season was 1951, which began early and, with the exception of the blue-winged teal, continued late; it is felt that the large number of water areas present through June stimulated continued nesting effort. On the other hand, the 1952 season began early but was not prolonged, possibly because of the rapid drop in water levels starting in early June. In 1953, a wet and cold spring, the early nesting mallards and pintails were retarded -- pintails to an even greater extent than in 1950. After the period of bad weather in April and early May, conditions became more favorable for nesting and the normally late-nesting blue-winged teal and gadwall were not noticeably retarded. Nesting for all species in 1953 was compressed into a shorter period than in any other of the four years. However, the productivity of the nesting population was at its highest in 1953, and there were fewer unsuccessful hens available for late renesting, even though conditions were favorable for it.

The total length of the brood season and its chronology is a highly variable item, as is shown by figures 14-18. These figures indicate by species the percent of the total brood population visible at any date during the season. They are an accumulation of all broods produced, each spaced along the abscissa with regard to its dates of hatching and flying. The percent of the year's production present on any date may be read directly from the curves. The number of broods per square mile of each species produced on the study area is indicated below the year dates.

The longest brood seasons were those of the mallard and pintail, which nest early, require considerable time to reach flying age, and are persistent renesters. In 1951, there were mallard broods present on the area for 148 days, and there were either mallard or pintail broods present for 162 days, or more than 5 months, from May 20 to October 29. This is in contrast to 1953 when broods were present for only 125 days, or a little over 4 months.

The total span of the nesting season is also reflected in the percentage of total brood production present in a flightless state at the period of peak density. For all species this varied between 82 percent in 1953 and 72 percent in 1951. When the species are considered individually, this variation is even more pronounced. For instance, 95 percent of all mallard production could be measured at the peak in 1953, but only 65 percent in 1951. If a specific date is considered, another variable is added, in that brood seasons of equal duration may peak at different dates. For instance, considering all broods combined, a count on July 20 of 1950 would have measured only 36 percent of the season's production, while in 1953 a count on the same date would have measured 67 percent. This difference can be decreased by making a count more nearly at the average peak date. A count on August 10 each year would have measured from 67 percent of all broods produced in 1951 to 75 percent in 1952 and 1953.

There is, therefore, considerable variation in the timing of brood use of an area, the early nesting species being more variable than the late nesters which are not so greatly affected by early spring weather.

In no case is it possible to pick out more than one definite peak of hatching. The only possibility is suggested by the relatively few pintail broods in 1951 and 1952. In all other cases, staggered dates of nest be-

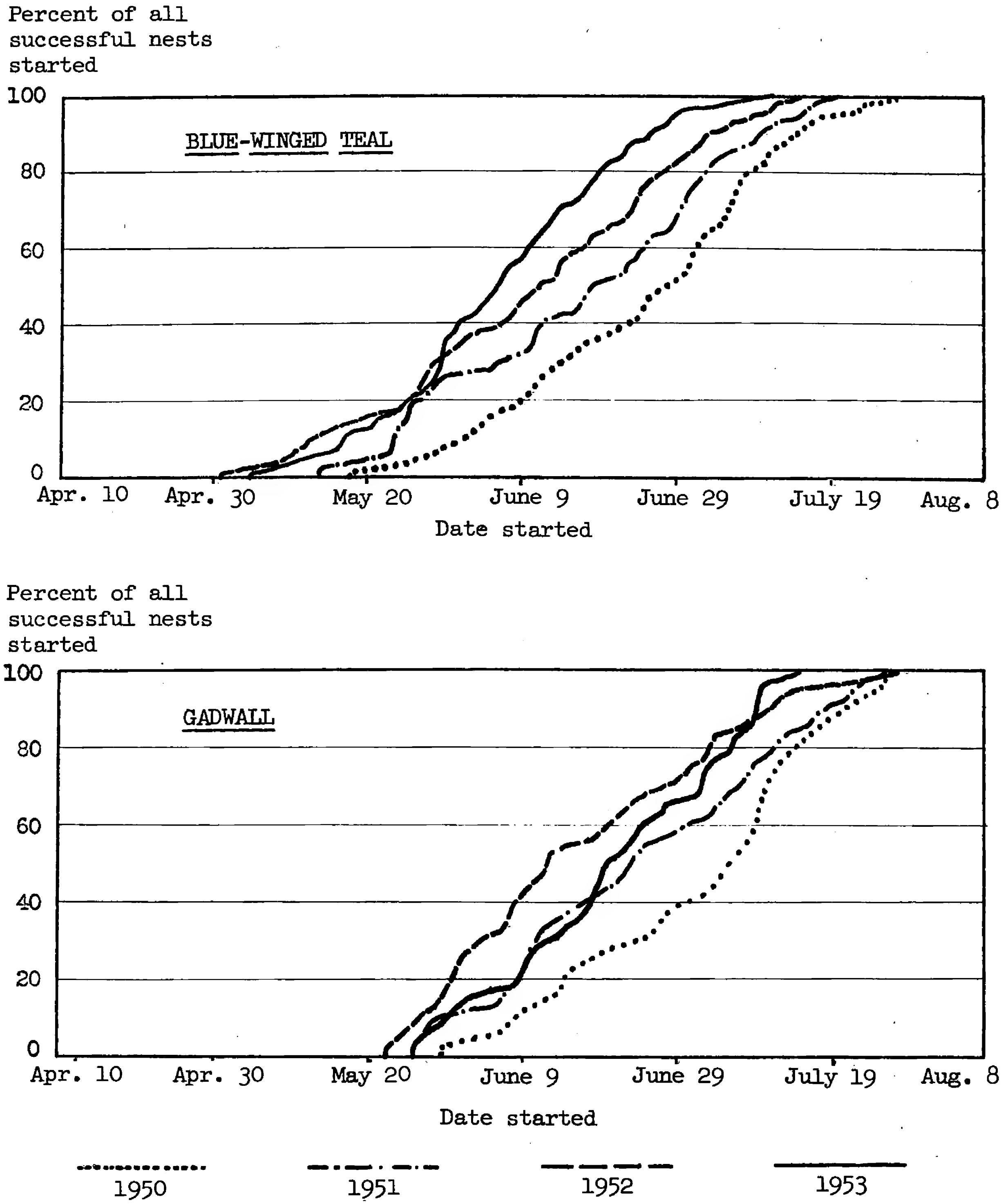

Figure 12.--BLUE-WINGED TEAL AND GADWALL: FIRST EGG LAYING IN SUCCESSFUL NESTS, 1950-53

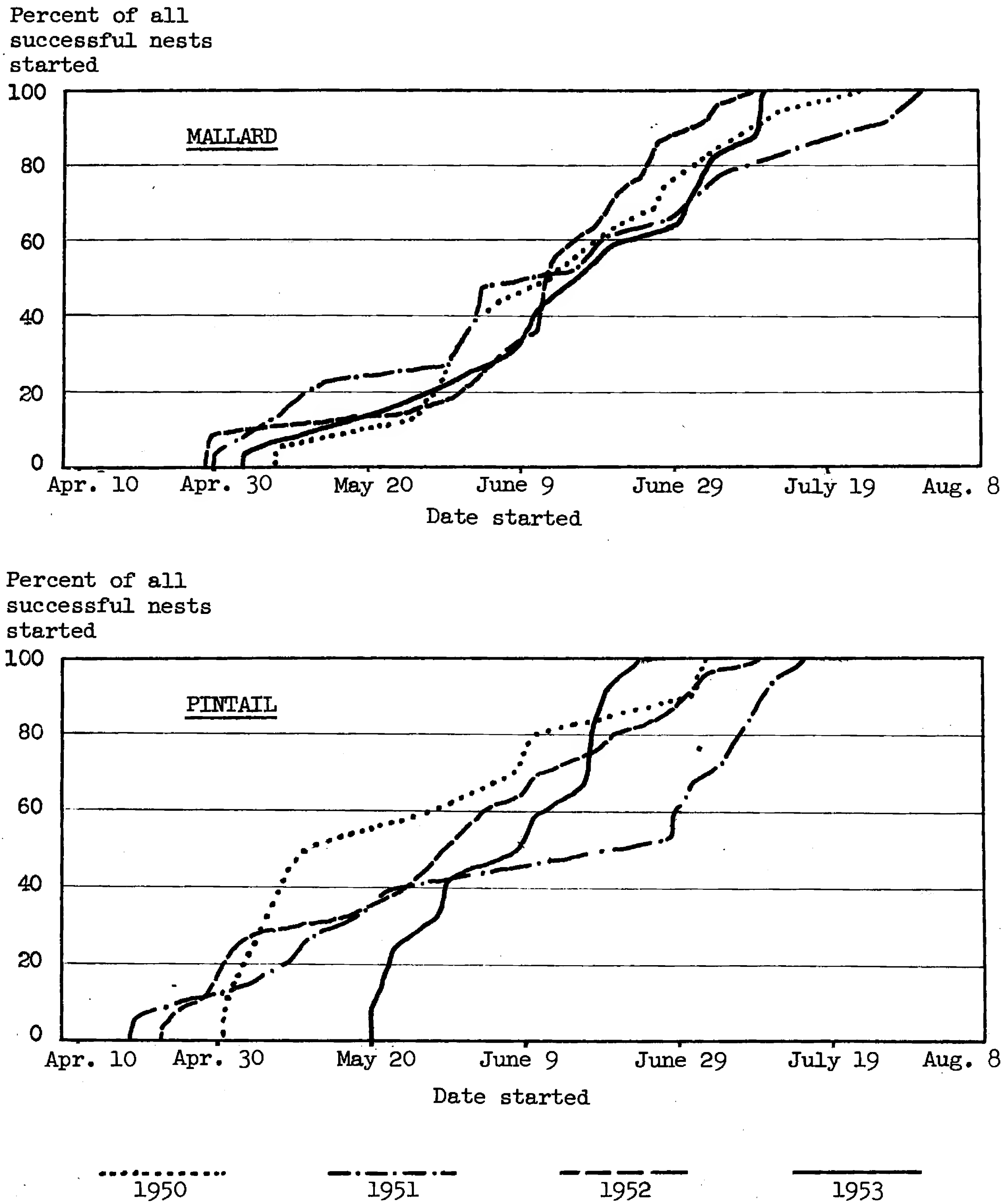

Figure 13.--MALLARD AND PINTAIL: FIRST EGG LAYING IN SUCCESSFUL NESTS, 1950-53

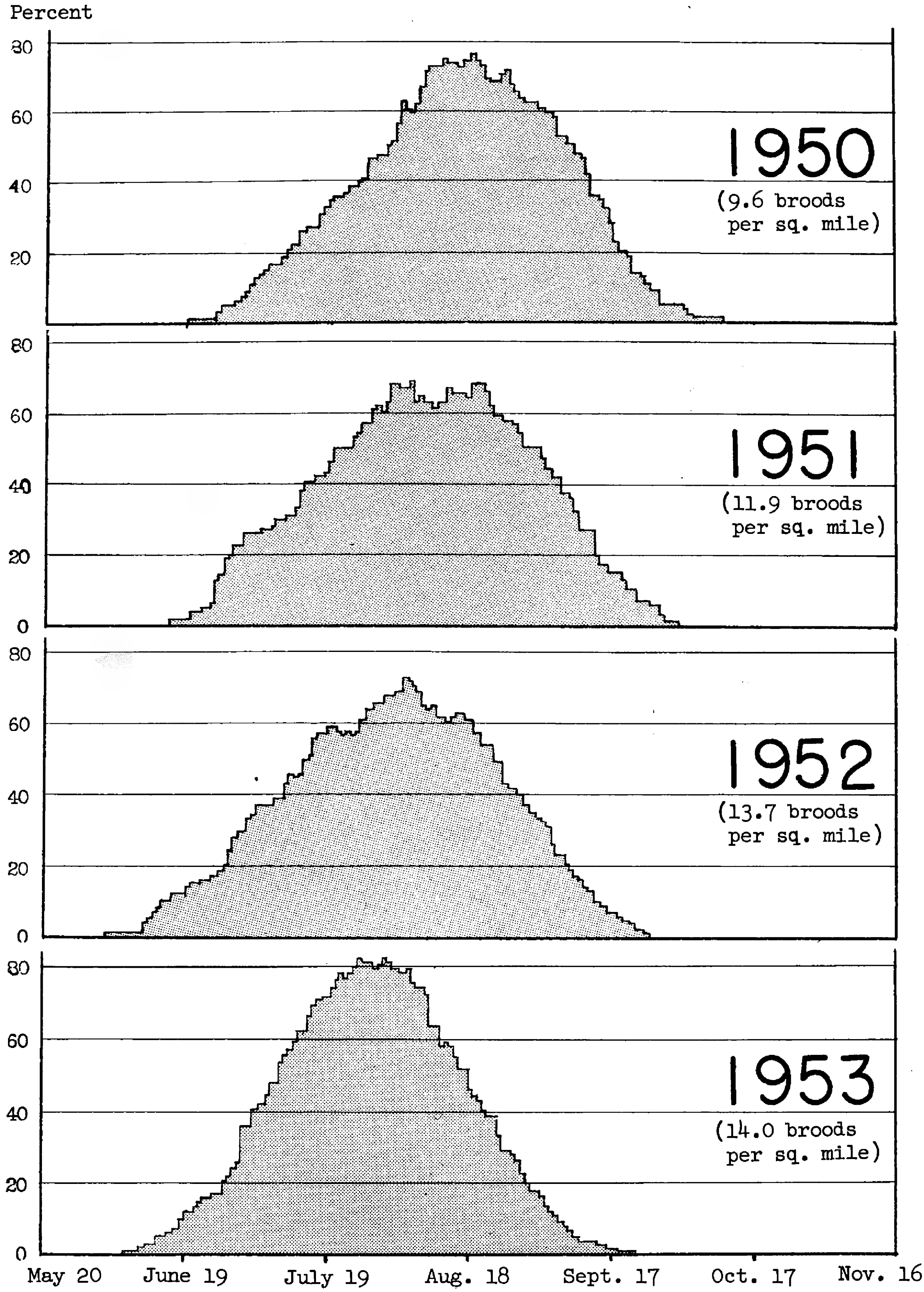

Figure 14.--BLUE-WINGED TEAL: FLIGHTLESS BROODS, EXPRESSED AS A PERCENTAGE OF ALL BLUE-WINGED TEAL BROODS PRODUCED, 1950-53
[See text for explanation of these graphs]

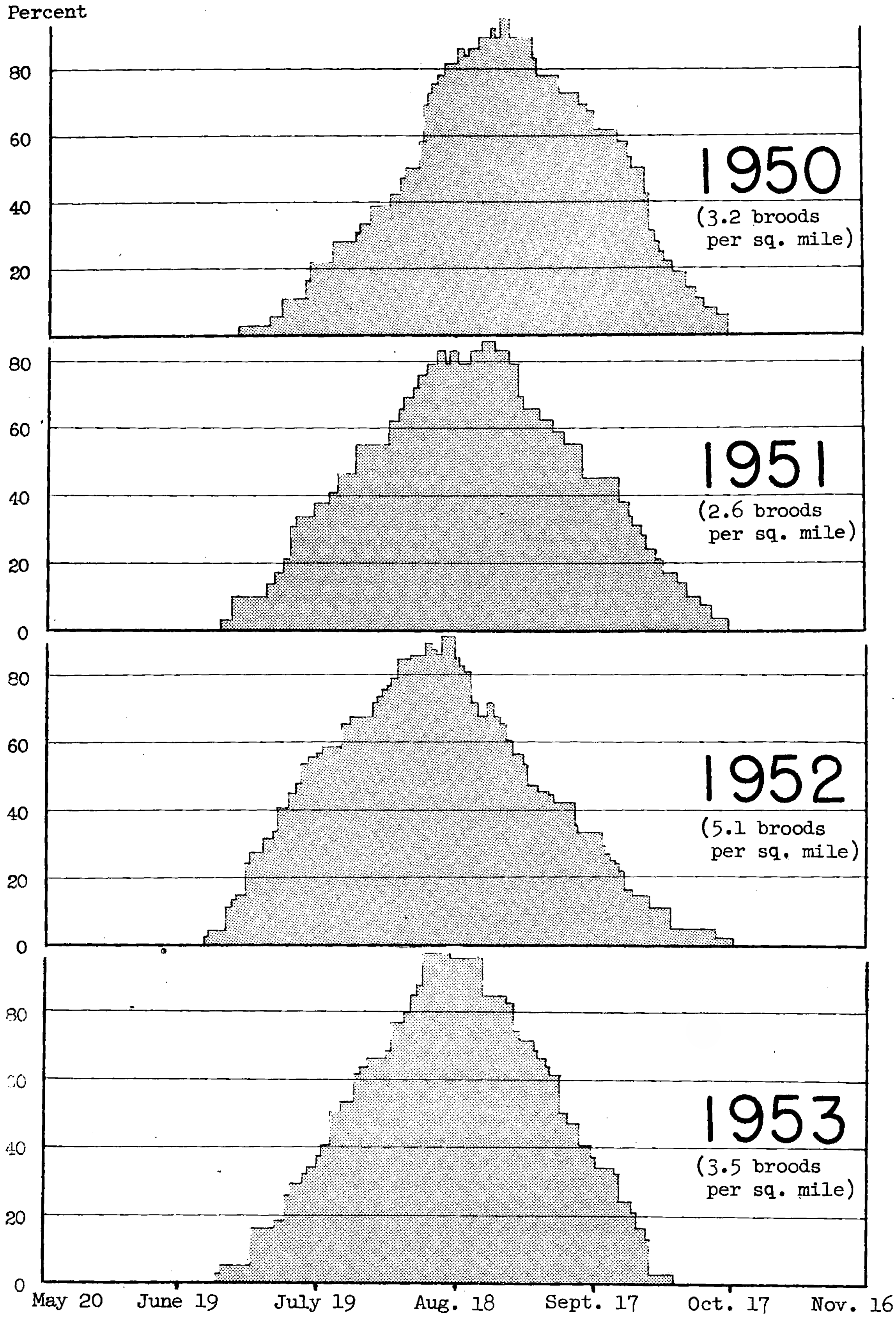

Figure 15.--GADWALL: FLIGHTLESS BROODS, EXPRESSED AS A PERCENTAGE OF ALL GADWALL BROODS PRODUCED, 1950-53
[See text for explanation of these graphs]

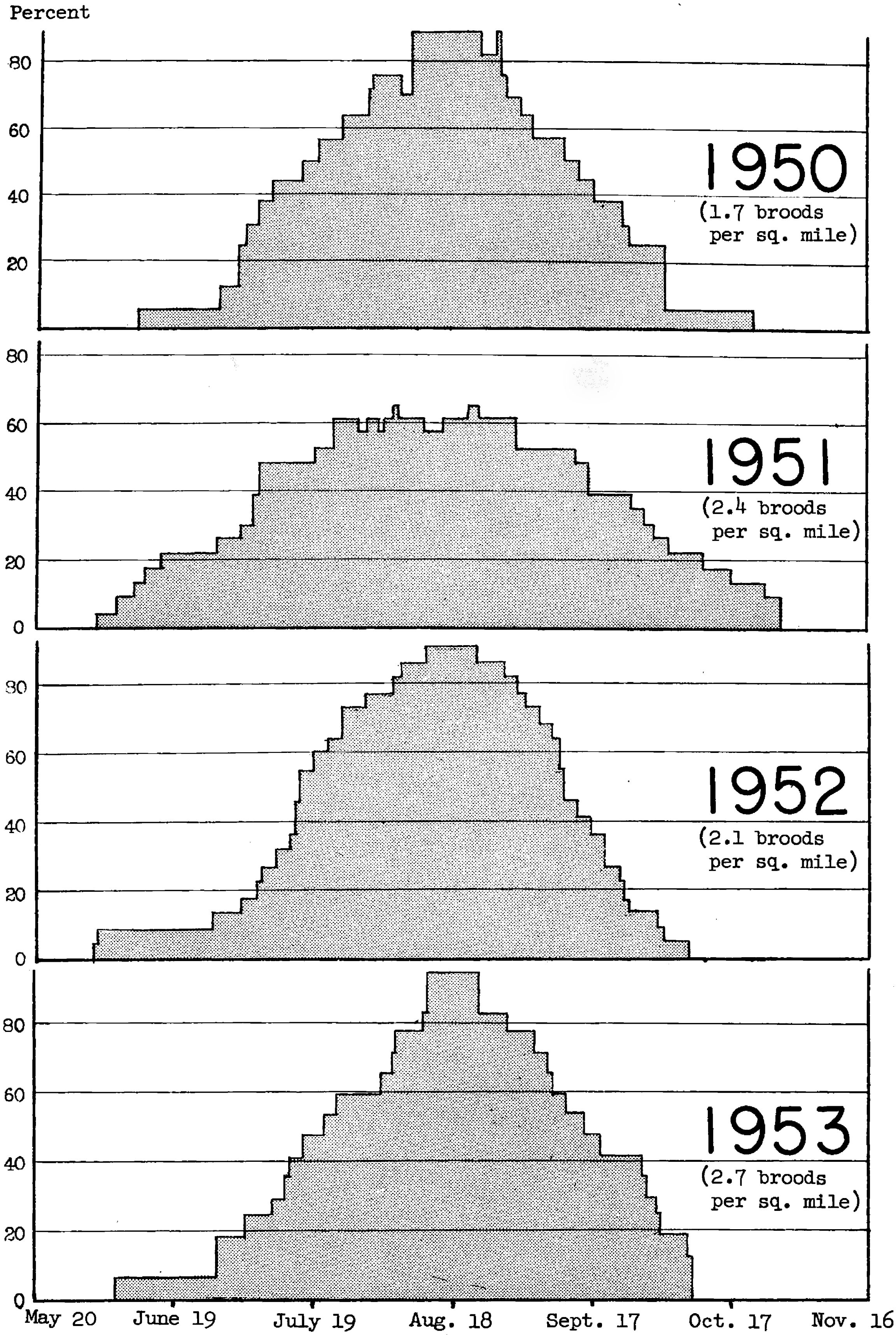

Figure 16.--MALLARD: FLIGHTLESS BROODS, EXPRESSED AS A PERCENTAGE OF ALL MALLARD BROODS PRODUCED, 1950-53
[See text for explanation of these graphs]

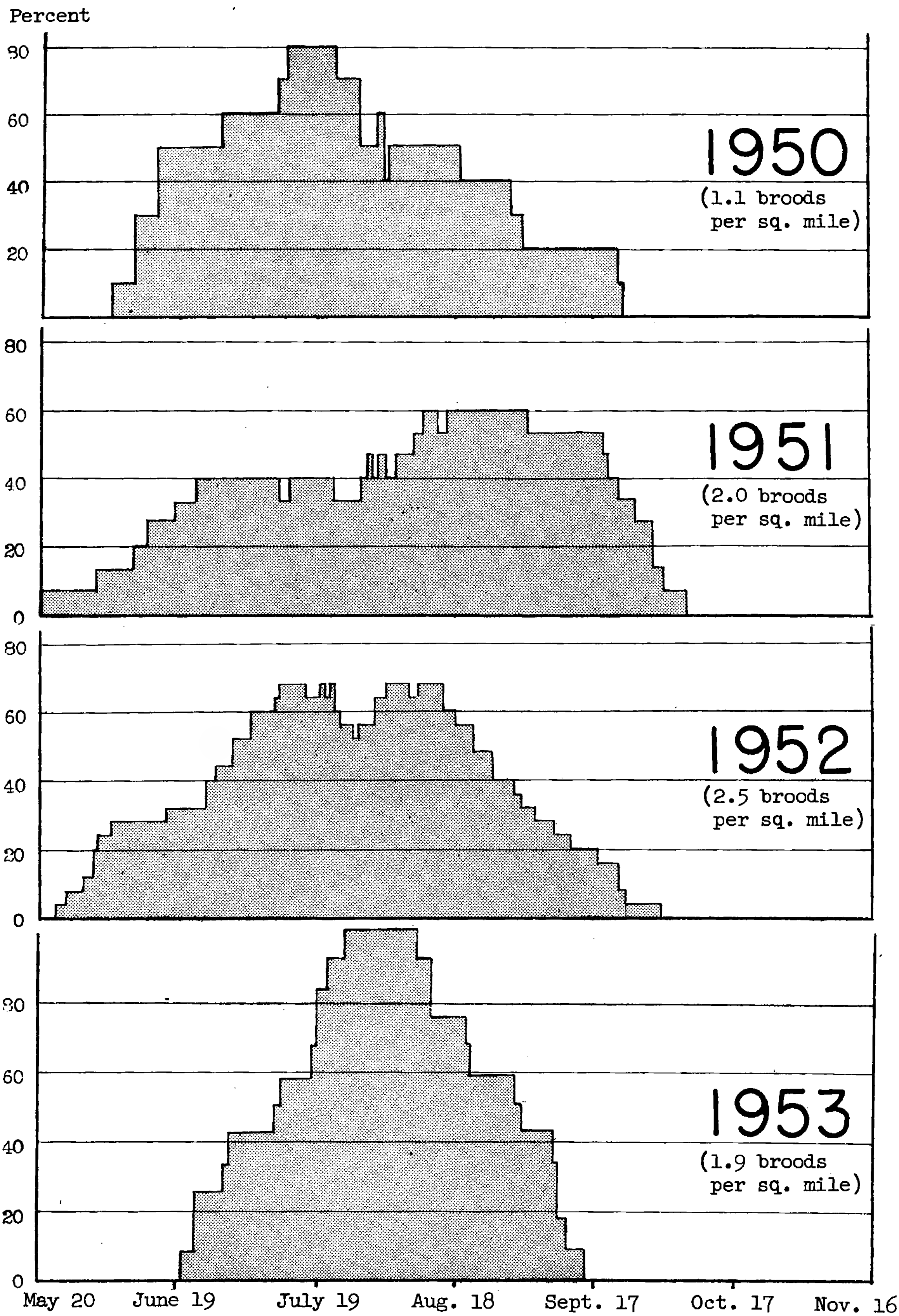

Figure 17.--PINTAIL: FLIGHTLESS BROODS, EXPRESSED AS A PERCENTAGE OF ALL PINTAIL BROODS PRODUCED, 1950-53
[See text for explanation of these graphs]

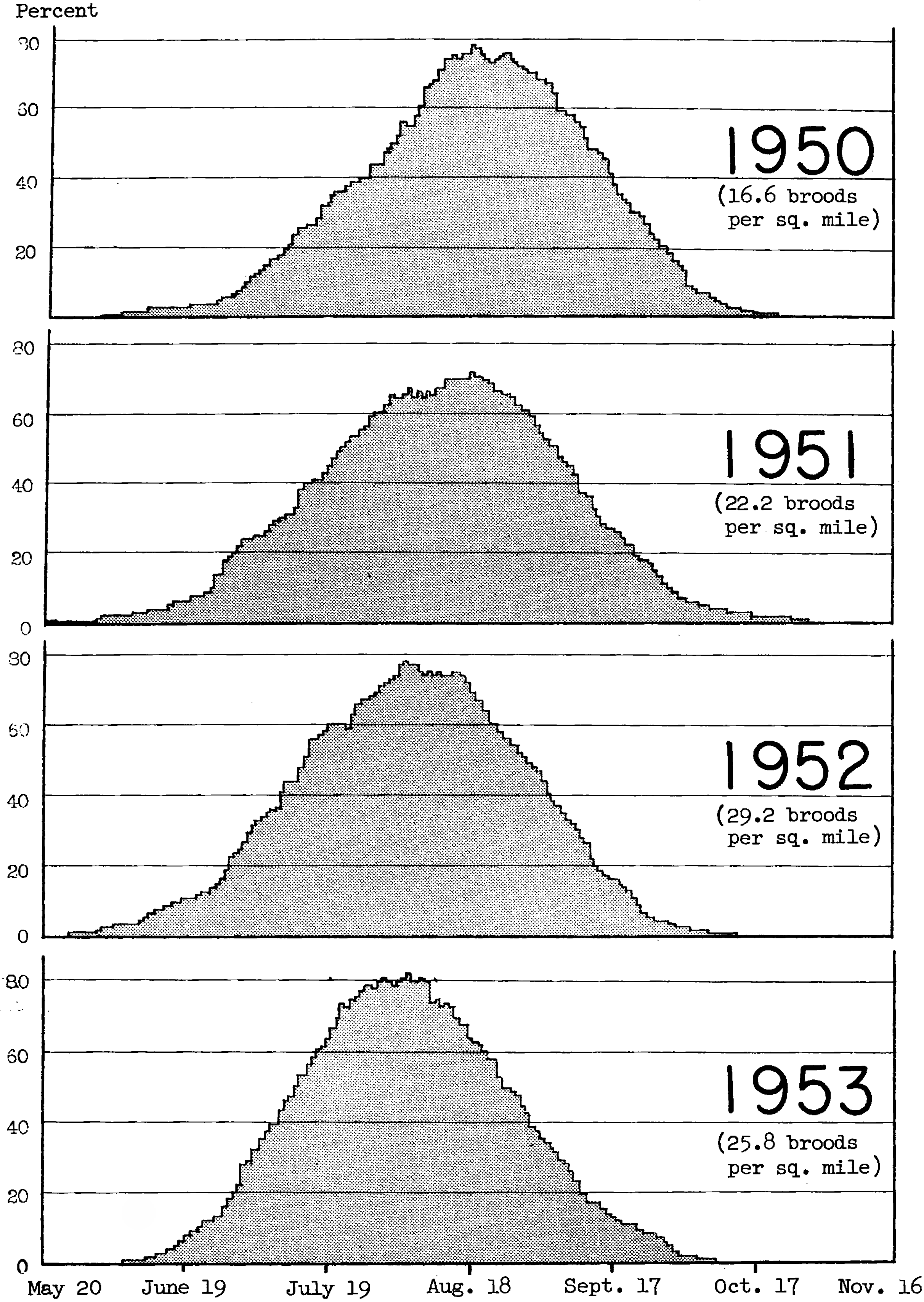

Figure 18.--SPECIES COMBINED: FLIGHTLESS BROODS, EXPRESSED AS A PERCENTAGE OF ALL BROODS PRODUCED, 1950-53
[See text for explanation of these graphs]

ginnings and the random effect of predation served to spread out the season. Brood populations rose gradually to a peak and then tapered off. The same situation was reported by Sowls (1951) for the Delta Marsh in Manitoba. Unless some widespread nest destruction such as a storm or flood should occur, there would be little chance of more than one peak of hatching. Even then, the individual variations between hens in the amount of delay before renesting could be expected to stagger the hatch.

POTHOLE UTILIZATION

Early arrivals

The relatively few spring migrants that used the area were generally gathered in groups and tended to favor the larger waters. Dabbling ducks used mainly the deep and shallow marshes, while the divers concentrated in the open-water areas. There were conspicuous exceptions to this, and groups of migrants, even divers, might be seen on temporarily flooded grainfields or hay meadows. Apparently, they congregated where there was open water that was easy to keep ice-free at night and where feeding conditions were favorable.

Breeding pairs

Resident birds, except for the earliest arrivals, tended to scatter out over the landscape and not to favor any particular type of water area. The earliest arrivals made use of areas not occupied by ducks at any other time. Table 9 shows the use of potholes of the various size classes by breeding pairs[1] during the peak of the breeding season in May and early June of the four years.

Pothole use varied inversely with size: the smallest, apparently least attractive areas received the heaviest use per acre, even though many were dry during much of the season. In the last column of table 9, the acreage of a pothole is included in the total for the size class only if it held water, and the use by ducks is considered in terms of water alone as it occurs in the various size classes. This illustrates what might be expected to occur if there were no variation in water levels and potholes of all size classes were relatively permanent. On this basis, there were 13 times as many birds per acre (8:0.6=13.3:1) on the smallest bodies of water as on the largest. It appears that the best distribution of a given amount of water for pairs only would be in the form of many small, relatively permanent areas available to the birds throughout the breeding season.

The size of the breeding population, as well as the availability of water areas, appeared to have considerable influence on this behavior. Table 10 shows the use of areas under 2 acres in size by pairs of blue-winged teal, gadwall, mallard, and pintail in 1951 (the only year in which enough breeding-season coverages of the study area were made to permit comparison).

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[1]Breeding pairs throughout this section refer to pairs, lone drakes, and lone hens.

Table 9.--Use of potholes by breeding pairs, 1950 to 1953

[Based on 4,910 pair observations and 3,152 pothole observations. Includes the 391 potholes shown in table 3]

Size class (acres)	Pairs per acre[1]				Average pairs per acre, 1950-53	Pairs per wet acre, 1950
	1950	1951	1952	1953		
0.0- 0.09	1.0	1.4	1.3	2.4	1.5	8.0
0.1- 0.3	.5	1.0	1.2	1.0	1.0	1.8
0.4- 0.9	.5	.9	1.3	.7	.8	1.0
1.0- 1.9	.7	.9	1.2	.8	.9	.9
2.0- 4.9	.7	.8	1.0	1.1	.9	.8
5.0-11.9	.7	.7	.8	.6	.7	.7
12+	.6	.5	.6	.5	.5	.6
All sizes	0.6	0.7	0.8	0.7	0.7	0.7

[1] Based on total acreage of size class even though some potholes of the size class are dry some of the time.

Potholes larger than 2 acres were clearly the preferred early-season habitat for blue-winged teal and gadwall. The data for the mallard and pintail were inconclusive in that regard, as the main breeding population of these species had arrived before the beginning of spring work that year. Breeding populations of blue-winged teal and gadwall were low at that time, competition for space was not acute, and the use of small areas was insignificant. As the population built up, pairs became crowded and the use of small areas increased. These data also indicate that the populations responded quickly to fluctuations in water levels. An increase in the number of available potholes in the period May 23 - June 3 was accompanied by a rise in the use by pintails of these small areas as the birds were able to distribute themselves more widely. A further rise June 4-13 in the number of areas available was accompanied by an increase in the use of small areas by pairs of mallard, gadwall, and blue-winged teal. Field observations in this and other years have detected a tendency in dry periods for the birds to congregate on larger potholes, making little use of the few small areas that remained. At those times, particularly June of 1950, the birds appeared to have lost interest in nesting. After a rain, when the number of potholes increased, the birds spread out over the countryside and could be seen on almost any puddle, making the greatest possible use of available space. This may possibly indicate a reduction in nesting activity during a period of overcrowding, followed by renewed interest when the birds could again spread out.

There was considerable variation between species in their distribution throughout the potholes. Table 11 indicates that the diving ducks generally remained on large water areas, while the dabblers were much more dispersed, making most of the use of small areas. As shown in table 10, which deals with

Table 10.--Breeding-pair use of small water areas, 1951

[Small areas are those of less than 2 acres; large areas are 2 acres or more. Each period includes one complete coverage of the study area]

Period	Number of areas holding water		Blue-winged teal		Gadwall		Mallard		Pintail	
	Large	Small	Total number of pairs	Percent using small areas	Total number of pairs	Percent using small areas	Total number of pairs	Percent using small areas	Total number of pairs	Percent using small areas
4/25-5/4	96	213	68	10	34	6	84	18	46	22
5/5-5/13	96	176	221	17	46	28	87	22	59	22
5/14-5/22	96	147	275	18	88	20	84	17	67	22
5/23-6/3	96	212	332	18	110	17	86	19	64	33
6/4-6/13	96	263	312	24	108	25	87	31	54	30
6/14-7/9	96	310	310	21	95	23	75	19	52	31

Table 11.--Average percentage distribution of breeding pairs, by species and by pothole size, 1950-53

Species	Percentage in potholes of--						
	0-.09 acres	0.1-.3 acres	0.4-.9 acres	2-1.9 acres	2-4.9 acres	5-11.9 acres	12.0+ acres
B-W Teal	0.3	2.8	5.8	10.2	20.7	25.3	34.8
Gadwall	.6	3.8	6.1	8.7	19.5	25.4	36.0
Mallard	.5	3.9	7.5	9.7	18.2	25.3	34.8
Pintail	.3	5.0	10.1	9.1	17.4	23.2	34.9
Shoveller	.9	2.2	4.9	7.6	21.1	24.7	38.6
Redhead	....	....	2.2	2.7	6.5	26.1	62.5
Ruddy	....	....	....	....	10.2	29.9	59.9
Lesser Scaup	....	....	1.2	2.4	8.3	17.9	70.2
Baldpate	....	2.4	....	2.4	12.2	19.5	63.5
Canvasback	....	....	....	5.0	10.0	25.0	60.0
G-W Teal	....	....	....	5.9	29.4	11.8	52.9
Other	....	....	....	5.0	15.0	35.0	45.0
All species	0.4	3.1	6.1	9.1	19.0	25.1	37.3
Percent of total acreage	trace	2.2	5.0	6.9	14.7	24.5	46.7

the effects of population sizes and water conditions, this variation may have been due as much to differences in abundance as to differences in habits. This possibility is given credence by the fact that the two infrequent dabbler species, baldpate and green-winged teal, make almost no use of small areas. The smaller, apparently less desirable, areas increase in importance as the breeding population of a species increases.

Although detailed analysis of the effect of cover on the use of potholes by breeding pairs is impossible, it was found that under average conditions potholes with excessively dense vegetation were very little used. Those with very sparse cover, or with no vegetation at all, were clearly preferred. On the other hand, a certain amount of cover was of value as wind shelter in cold, blustery weather. Birds were often noticed using shelter in such weather, while they almost completely deserted open wind-swept potholes.

Other factors affecting the distribution of breeding birds should be mentioned. Although no intensive work was done at Waubay on food supply, inspection of the potholes indicated abundant food in nearly all of them. Not only was a good supply furnished by vegetation, but invertebrates were particularly abundant, even directly after the ice went out in the spring. To test the influence of food on the distribution of ducks in May of 1952, several bushels of wheat and corn were placed on the shore and in the water of a pothole moderately used by blue-winged teal, gadwall, mallard, and pintail, and also frequented by most of the other species. None of this grain was touched by the ducks or even by the abundant blackbirds and mice in the area. Benson (1948), after careful analysis of available food and its use in a series of prairie ponds in Minnesota, also concluded that space requirements, rather than food, controlled the distribution of blue-winged teal.

Land use, except for its effects on the vegetation of the potholes, has not been found to have any influence on the distribution of breeding pairs. Even the disturbing effect of farm buildings immediately adjacent to a pothole did not reduce its utilization. Intensive land use, involving the plowing or burning of the entire pothole, often improved it for pair use by removing excess plant cover.

It is improbable that water chemistry was a factor in the use of potholes by ducks. Although no samples were taken, the vegetation indicated that there were no extreme chemical variations. However, there were in the general region a few relatively barren areas of high alkalinity which were little used by waterfowl. Owing to high water levels in 1952, one such area became highly attractive to ducks, and remained so in 1953, presumably because its high alkalinity was diluted.

About the only water areas that were not used by ducks during a breeding season were those excessively overgrown or extremely alkaline. Because of changes in land use and water levels which modify these factors, even most of these are suitable during some years.

Thus, the distribution of breeding ducks appears to be influenced primarily by a tendency toward dispersal, particularly in the case of the most abundant species. Hochbaum (1944) and Sowls (1951) discussed territoriality

in waterfowl and concluded that the desire for isolation from other members of the same species is an important factor during the breeding season. It appears that this desire for isolation in the pothole country leads to a dispersal of the population and brings about intensive use of parts of the habitat which are not otherwise used.

Distribution of nests

Although the work at Waubay did not involve intensive nesting studies and the sample obtained was probably not representative, 294 nests were recorded. Of this number, 95 were in the emergent vegetation of potholes. These include 48 of the 86 mallard nests and all but 2 of the 48 diving-duck nests. Hardstem bulrush was by far the preferred cover for these species; cattail, whitetop, and other plants contained only a few nests.

Over-water nests were distributed fairly evenly throughout the pothole sizes above 1/2 acre, while only one nest was found in a smaller area. Depth and water-level fluctuations are definitely the important factors in controlling the emergent vegetation, and hence the selection of cover for nesting. The great majority of these nests were found in either shallow or deep marshes which go dry from time to time and which had the best developed growth of emergent vegetation.

Forty (42 percent) of all over-water nests found were in three deep marshes. All of these were found in 1950, 1951, and 1953, since in the high-water year of 1952 the emergent vegetation of these areas was completely flooded out and unusable for nesting. Most suitable nesting cover in 1952 was found in areas with overflows, which controlled water levels and prevented flooding, or in a few potholes where levels had previously been below normal.

The remaining 199 nests, all of puddle ducks except two of lesser scaup, were scattered throughout available cover and showed a slight tendency to cluster in the vicinity of potholes. This clustering tendency was not particularly significant, since in this type of country there were few places for ducks to nest which were more than 300 yards from water. Nesting in the bottoms of dry potholes or in the pothole margins generally occurred in areas of medium or low permanence, where the rapid drop in water levels made such cover available for dryland nesting early in the spring.

It is probable that the majority of successful upland nests were in standing small grain which covered 63 percent of the study area. Local residents have told of finding a nest for every 15 acres when they swathed the grain in August. Considering the size of the breeding population and the number of broods produced, as well as the late date, this is a high concentration of nests. Furthermore, although the intensity of censusing for upland nests was fairly constant throughout the season and although a hunting dog was used two years of the four, very few nests were found after July 10. Referring back to figures 12 and 13, and allowing roughly 30 days for laying and incubation, less than 40 percent of all successful nests had hatched by July 10 in the four years of the study. Standing small grain is the only type not censused and becomes available as nesting cover about July 1. It thus appears certain that the majority of late-season broods of upland-nesting species were hatched in this type.

The location of nesting cover and of the nests themselves had only a slight influence on the distribution of breeding adults. Diving-duck pairs appeared to locate themselves in the neighborhood of nesting cover, but not necessarily in the same pothole. An exception to this was the ruddy duck, which apparently paired, nested, and raised its young mainly in one pothole. In only one case was nesting cover found to influence the distribution of breeding river ducks. This took place during the first two years of the study in the southwest corner of the study area, where 20 mallard nests were found in one hardstem-bulrush pothole and populations of this species were of more than average density in the immediate vicinity. In 1952, when the bulrush of this pothole was flooded out and useless as nesting cover, the use of the surrounding square mile by mallards was below the average for the study area. In 1953, use of the surrounding area by mallards was up, but late spring rains flooded out most over-water nesting and only one mallard nest was found in the pothole.

Innumerable nest-hunting attempts by many observers have led to the conclusion that the nest of a pair of ducks is not generally located in or adjacent to the pothole on which the pair has been seen. At Waubay, the nest of one marked blue-winged teal hen was found more than a mile from the pothole on which the pair was seen most frequently, although it was within 50 yards of another pothole they were known to frequent. Two observations made at Minnedosa, Manitoba, by Evans et al. (1952) also support this conclusion. There, two blue-winged teal nests were found immediately adjacent to a pothole which was under observation at least twice daily, yet this pothole was never known to be occupied by this species. On one occasion, one of the hens was seen to leave her nest voluntarily and fly to a distance of at least half a mile, presumably to join her drake or to feed. Engeling (1950) found that the nest of the mottled duck in Texas may occur anywhere within the range of the pair, or even outside it.

Although most species show at least a slight tendency to nest near water, it is not generally near the water on which they spend the most of their time. General observations of the behavior of birds and the distribution of nests gave the impression that they spent as little time as possible in the immediate nesting area.

Broods

The distribution of broods differed considerably from that of breeding adults. There was no longer a tendency to disperse, and there was a greater selectivity for definite types of water areas.

Broods generally preferred the larger water areas, although data for 1951, 1952, and 1953, when water levels were high, indicate that there is an upper size limit to preference, since areas of 2 to 5 acres were used more heavily than larger ones. During the brood season, most of the very small potholes (under 1 acre) were dry. Those that did retain water, or became refilled, were still not used by broods to any measurable extent.

Most broods were found in open-water areas and deep marshes, as shown in table 12. In the high-water years of 1952 and 1953, there was an increase in

Table 12.--Percent of broods in each wetland type, by years, 1950-53

[Based on 1,618 brood observations]

Wetland type	Percent of total pothole acreage	Percent of broods 1950	1951	1952	1953	Average
Intermittent areas	2.2	0.0	0.0	0.0	0.0	0.0
Temporary marshes	3.8	0.0	0.0	0.0	1.3	.3
Shallow marshes	8.6	2.3	.2	2.6	2.9	2.0
Deep marshes	43.6	20.4	29.3	41.4	39.4	32.6
Open-water areas	41.8	77.3	70.6	56.0	56.6	65.1
Total	100.0	100.0	100.0	100.0	100.0	100.0

the use of the deep marshes and shallow marshes, and a decrease in use of open-water areas. This was probably due to the thinning of marsh vegetation by rising waters. Many of the areas heavily used in 1952 and 1953 were dry during most of the brood season in 1950, and shallow or dry in 1951. Furthermore, some of the large open-water areas previously much used were so bare and windswept in 1952 and 1953 as to be less attractive to broods.

Much of the use of the marsh areas occurred early in the season, with broods appearing more and more on open water as the season progressed and the smaller, less permanent areas developed dense vegetation and decreased in depths, becoming unattractive. This was particularly marked in 1951, when no broods were found on open-water until 1 month after the first brood was seen, and not until 26 broods had been counted on marsh areas.

Species differed considerably in their preferences. Table 13 indicates that the diving ducks and the gadwall definitely favored open water areas. The other river ducks, particularly the mallard and the pintail, made much more use of the deep marshes. The ruddy duck was somewhat intermediate.

Observations of brood behavior have indicated that the selection of brood-rearing habitat depends on the availability of a means of escape from predators. This may be furnished by cover sufficient to conceal the brood but not so dense as to restrict the movements of the young. On the other hand, a means of escape may be provided by open water of sufficient size and depth that broods can dive to escape their enemies. The first means of escape is furnished most often by deep marshes and the margins of some of the open-water areas, particularly those in which the vegetation is undisturbed. This is the type of habitat sought primarily by puddle-duck broods. The large open areas, deep enough to furnish escape by diving, are heavily used by diving-duck and gadwall broods, whether or not good escape cover is available.

Some generalizations about habitat preferences of broods on the Waubay area may be made:

1. No broods were found in less than 5 inches of water in any cover type.

Table 13.--Average percentage of broods using each wetland type, 1950-53

[Based on 1,618 brood observations]

Species	Number of observations	Percentage of broods using-- Intermittent areas	Temporary marshes	Shallow marshes	Deep marshes	Open-water areas
B-W Teal	801	....	0.5	2.9	36.6	60.0
Gadwall	261	....	....	....	17.2	82.8
Mallard	177	....	....	1.1	44.1	54.8
Pintail	129	....	0.8	3.1	38.0	58.1
Shoveller	46	....	....	4.4	32.6	63.1
Canvasback	9	....	....	....	11.1	88.0
Redhead	54	....	....	....	5.6	94.4
Lesser Scaup	15	....	....	....	....	100.0
Ruddy	116	....	....	0.9	34.5	64.7
Other	10	....	....	....	40.0	60.0
All species	1,618	....	0.3	2.0	32.6	65.2

2. Potholes less than 1 acre in size were not heavily used by broods.

3. Species may be tentatively rated in order of decreasing demands for deep water as follows: canvasback, lesser scaup, redhead, gadwall, ruddy duck, baldpate, shoveller, green-winged teal, blue-winged teal, mallard, and pintail. They also rate in the same order with regard to increasing demand for, and use of, escape cover.

4. Areas with no cover were used by broods if they were at least 20 inches deep and 5 acres in size.

5. River-duck broods (except gadwall) made free use of areas as small as 1 acre and as shallow as 5 inches provided that good escape cover was present.

6. Potholes less than 20 inches deep and 2 acres in size, and totally overgrown, were seldom used by diving-duck or gadwall broods.

7. A rise in water levels may lead to increased brood use of marsh types, as shown in table 12.

The same statements regarding the influence of food and water chemistry on the distribution of pairs may be applied also to broods. Although no detailed studies were made of food requirements or available food, it appeared to be abundant in all potholes. There were a few potholes which, in the late summer of 1950, appeared to be turning alkaline as water levels dropped and dissolved solids became more concentrated. However, they were by that time so shallow that it is doubtful whether broods would have used them in any event.

Land use, particularly grazing intense enough to completely remove the plant cover, may render unsuited to brood use some of the smaller, shallower potholes which might otherwise be used. Human interference such as continual activity, even of a violent nature, such as a brood beatout, does not diminish use except for the occasional brood driven ashore during the actual beatout. Even that brood is likely to return once the activity has subsided.

Flightless adults

Moulting ducks on the study area were a rarity, and none were seen until 1952 when three flightless hens were found in deep marshes. It appears that there is not ordinarily deep enough water in the emergent vegetation on potholes of sufficient size to satisfy the needs of birds in this condition. Whatever the cause, potholes on the study area were of no importance in this regard.

Flying juveniles and fall migrants

Flying juveniles and fall migrants made heaviest use of the larger potholes, generally deep marshes or open-water areas. Gadwall, baldpate, blue-winged teal, and shoveller showed preference for open water, while pintails favored areas with more cover and mallards were intermediate. There were too few diving ducks present in late summer and fall to indicate preference. Selection of habitat by all species at that time was extremely haphazard and seemed to depend as much on a flocking tendency as on other factors. At this season, food was an important consideration, and gatherings might often be found in areas where there were beds of arrowhead or pondweeds.

With the advent of the hunting season, many ducks were driven off the large open potholes. Such mallards and pintails as did not leave the region entirely were often found in the deep marshes. There they were seldom disturbed; no hunters were seen "jump shooting" these overgrown areas.

The changing needs of the ducks were well adapted to the seasonal variations in the habitat. Breeding pairs seeking isolation could find it in the abundant small depressions filled by melted snow and spring rains. During the early part of the nesting season, most areas had little cover, as all but the toughest vegetation had been beaten down during the winter. Later, in June, when the broods were hatching, many of the temporary areas and shallow marshes were dry, but by then the desire for dispersal had decreased and the birds could freely move into the larger more permanent areas. They were then more concerned with the shelter provided by the season's new growth of vegetation. In the course of even one breeding season, a pothole that did not play some part in duck production was a rarity; in the course of several years of varying climatic conditions, every depression capable of holding water on the Waubay study area was used by ducks and, because of that use, probably has a value in duck production.

MOBILITY OF DUCKS IN THE BREEDING SEASON

Breeding pairs

One of the most important considerations in a study of the use of habitat is how readily, and for what distances, the ducks can move: how must the habitat be distributed in order to meet the needs of the birds? Hochbaum (1944) has defined territory as an area defended against other males of the same species and where the pair spends most of its time: an area having water, a loafing spot, nearby nesting cover, and food.

There is, in pothole country, a modification of this pattern as indicated by movement of birds from water area to water area. Repeated observations on a series of potholes in 1951 showed that pairs did not generally remain for any length of time on one pothole but moved from one to another.

In 1950, a pair of cinnamon teal took up residence on the study area. Since this species is extremely rare in eastern South Dakota, it was assumed that there was only one pair in the locality. Figure 19 shows where one or both members of this pair were seen on occasions from June 20 to July 26. It is safe to assume that they also used other potholes, since several other visits to the entire area south of the road and the two potholes northeast of the intersection failed to reveal the birds.

In 1952 and 1953, observations were made on birds individually marked for recognition. Enough was learned from these birds to demonstrate clearly that the blue-winged teal has a definite home range which encompasses a variable amount of land and includes several potholes. Figure 20 shows the minimum home range of one of the better-known pairs. The pair together was seen on seven different potholes, and the drake alone was seen on six. Most of these localities were defended by the drake. This home range was also used by other pairs with overlapping home ranges. The only friction occurred when a second pair appeared at a pothole at the time this resident pair was using it. The maximum size of the average home range was not determined by this study, but it was possible, by plotting upon a map all the potholes used by a marked pair, to compute the mean radius[2] of the minimum home range. The home range could be no smaller, but it could be, and probably was, larger. It should be emphasized that a pothole, even if used many times by a pair, was used only once in computing the mean radius, since some potholes (trapping sites, for instance) were under observation more of the time than were others.

Mean radii of the home ranges of 11 pairs, determined by this method, averaged 0.18 mile and varied from 0 (one bird observed several times was always on the same pothole) to 0.44 mile. Several territorial sites within each of these home ranges were, in many cases, defended in the manner described by Hochbaum (1944) as territorial defense. One loafing log appeared to fit the familiar picture of a nesting territory, as a pair of teal was seen resting there for several days. However, when the trap was set up by this log, four

[2] The mean radius is determined by establishing the midpoint of a number of observations, measuring the distance from that midpoint to each observation, and calculating the mean or average distance.

pair were captured. What had been assumed to be the territory of one pair was apparently a zone of overlap between the home ranges of four pairs.

Although we were unable to obtain significant data from marked birds of other species, it was evident from our repeated observations on a series of potholes in 1951 that the blue-winged teal had a relatively small home range compared with most other species. However, the general pattern appeared to be similar for at least the other puddle ducks. The potholes studied did not contain enough diving ducks to provide comparable information.

Sowls (1951) found on a large marsh the same situation with respect to home range and territory as has been found on the Waubay study area. He noted that the area occupied by a pair of ducks during the nesting season may be better thought of as a home range, any part of which may be defended, depending upon the immediate reaction of the birds at the time. It appears that what the drake may be defending is his own proximity rather than a definite area; what causes him to be intolerant of other birds of the same species at one time and to be sociable an hour or so later is not known.

The pair during the nesting season is therefore considerably more mobile than is often suspected. The area occupied by the pair is of considerable extent and the birds are able to react to changes in the habitat merely by moving to another more suitable pothole. Furthermore, this home range is not an area from which other pairs of the same species are excluded, and the home ranges of several pairs of the same species may overlap. The conflict between pairs when they come into proximity leads them to space themselves out and is very probably the factor which determines the carrying capacity of the habitat.

Broods

Once the eggs have hatched, the home range breaks down and the hen and brood, with a set of requirements and preferences different from those of the breeding pair, go off on a trek of their own. Figure 21 shows where 18 broods, individually marked on the nest in 1950, 1951, and 1953, were found after hatching. In no case was the actual route of travel or the ultimate destination of these broods known. Even the four broods found on the pothole nearest their nests may have done some traveling between observations or after the last observation. The longest trip of 2-1/4 miles, made by a blue-winged teal brood, was accomplished before the brood was 2 weeks old.

Movement overland did not seem to represent anything related to "home range." It appeared to be completely random, and there was no tendency to return toward the vicinity of the nest. No cause, such as drought or disturbance, could be found to account for such movement. Although in some cases the pothole near which the brood hatched had dried up or become obviously unsuited to brood use, broods which left such potholes and were subsequently seen again must have, in the meantime, passed through suitable potholes which may or may not have been occupied by other broods of the same species. As had been pointed out for the Manitoba parkland (Evans et al. 1952) such movement appears to be initiated by the hen, since no broods without hens were known to move overland. Furthermore, the hen can be assumed to be oriented to the landscape while she remains with the brood, as such hens were frequently

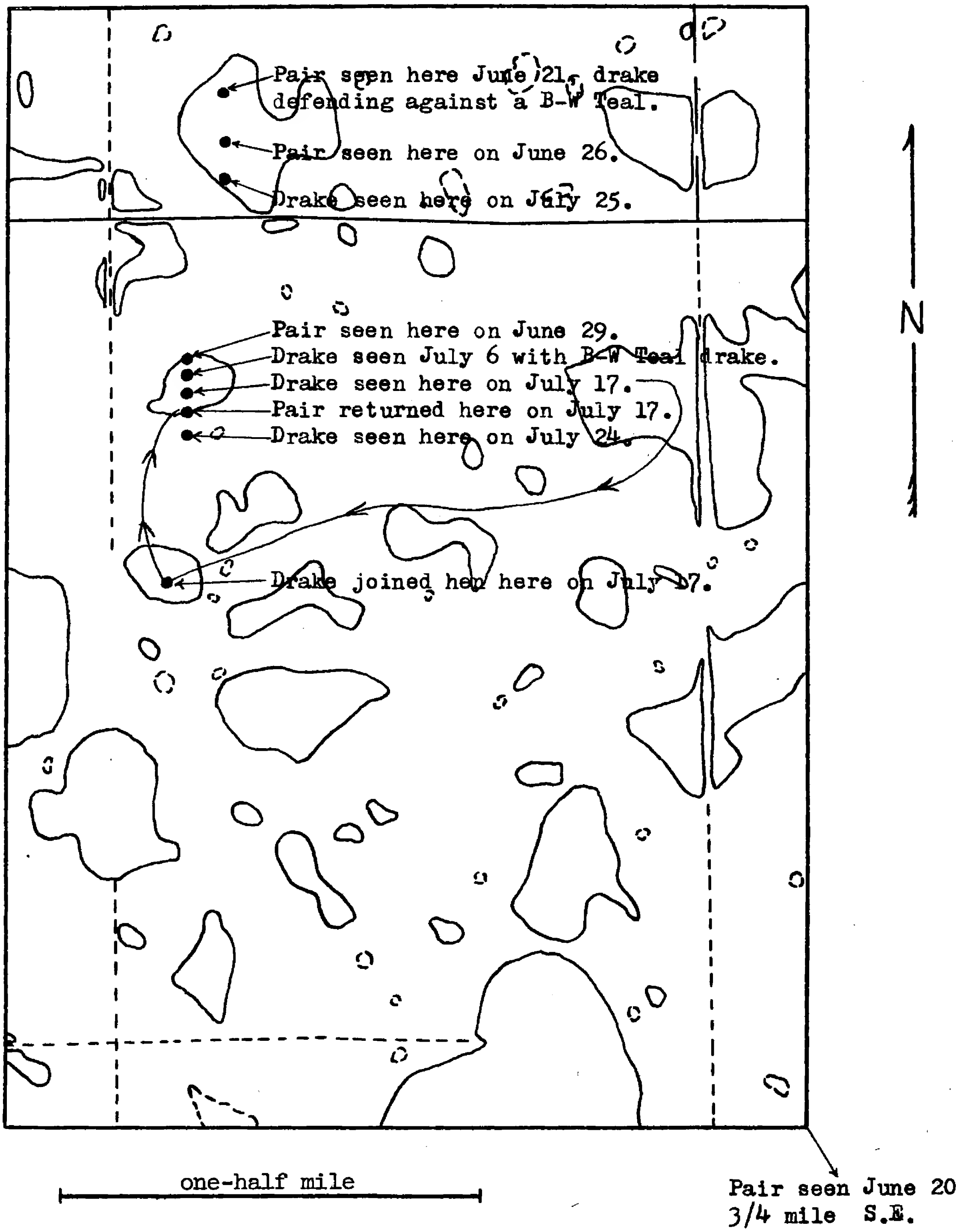

Figure 19.--MOVEMENTS OF A CINNAMON-TEAL PAIR, WAUBAY STUDY AREA, 1950.

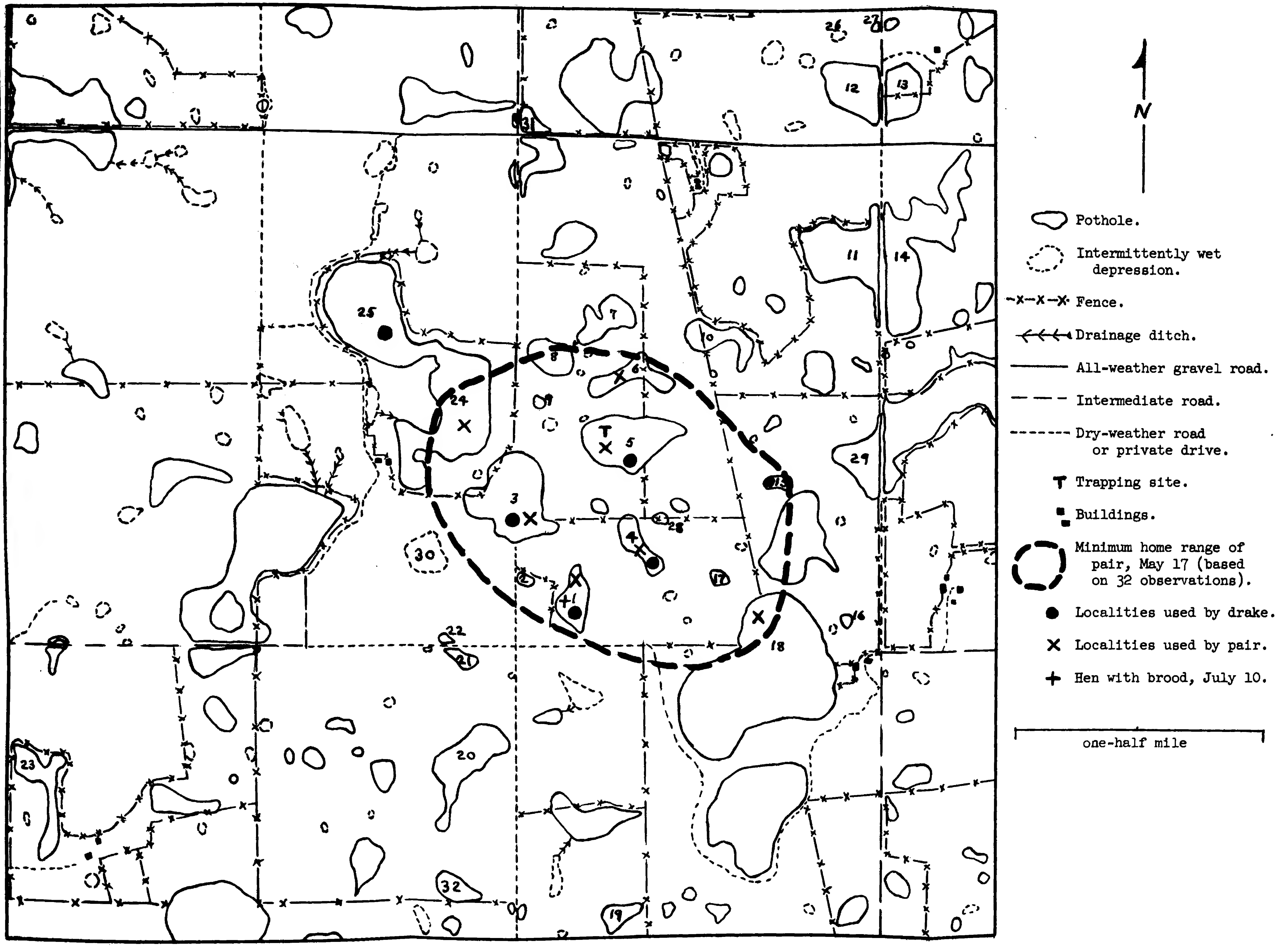

Figure 20.--POTHOLES USED BY A MARKED PAIR OF BLUE-WINGED TEAL, WAUBAY STUDY AREA, 1953. (The hen of this pair was originally banded as a duckling, on pothole 24, July 24, 1950)

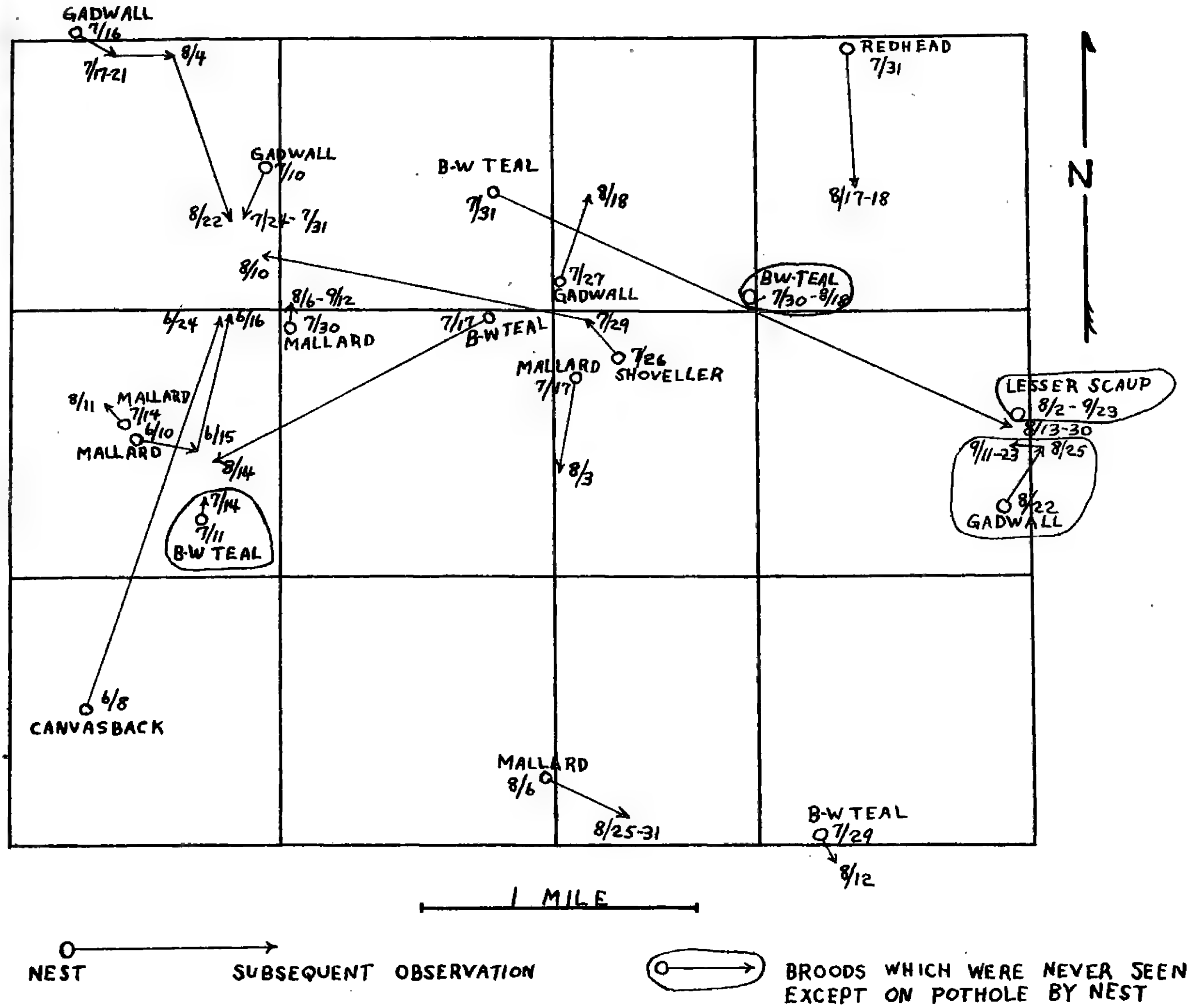

Figure 21.--MOVEMENTS OF 18 MARKED BROODS ON WAUBAY STUDY AREA

seen to leave their young for periods of an hour or more, make flights around the area and return. These movements were not always from poor to perceptibly better potholes, but were never to areas obviously poorer than those last occupied.

Different species vary in their ability and willingness to move overland. Table 14, (adapted from Evans et al. 1952), shows the relative mobility of broods of the seven species most commonly found in the pothole country at Minnedosa, Manitoba. These data indicate that the pintail, canvasback, and mallard are by far the most mobile, and travel overland many times more often

Table 14.--Relative mobility of duck broods at Minnedosa, Manitoba, 1949
[From Evans et al. 1952]

Species	Number of observations	Average number of days per pothole
Pintail	31	5
Canvasback	60	7
Mallard	53	7
Redhead	16	11
Blue-winged teal	37	11
Baldpate	15	20
Ruddy	10	[1]33

[1] The study terminated before many broods of this species had reached flying age, so this figure is low.

than the baldpate or ruddy duck. All but the ruddy duck, only one brood of which was found to move overland, generally made use of several potholes between hatching and flying.

There is no evidence that such movement brings about an increase in losses to predators, and since such movement is toward better habitat it is very likely that the opposite is true.

These data concerning the mobility of pairs and broods clearly indicate that most species of ducks may often move a mile or two with little difficulty. Fair-weather loafing sites for the pair need not be on the same pothole as cover used in stormy weather, which can be at a considerable distance. It is desirable that nesting cover be somewhere nearby, but it need not be adjacent. Furthermore, it can be at a considerable distance from permanent brood water, since a brood can easily travel a mile or so to water as the potholes used by the pair dry up.

USE OF THE HABITAT AND THE LIMITING FACTORS

We have noted something of the relation of the changing requirements of the breeding population to a highly variable habitat. It has been pointed out that breeding birds in the spring were responsive to conditions that enabled them to disperse and remain separated from other pairs of the same species. They showed little preference for areas especially attractive from the standpoint of food, cover, or any other measurable factor. Clearly, at this time they sought space and freedom from interference, and it is probable that the ability to find such isolation had an effect on the productivity of the birds as individuals, as well as on the carrying capacity of a given area. We have seen that the ability to disperse, as determined by spring runoff and rains, was highly variable from year to year, even between four "near normal" years.

The only requirement for nesting was the proper type of cover at the nest site. Other factors, such as the quality of the nearest pothole, were secondary. The availability of good nesting cover depended considerably on farming practices in the case of upland nests, and on water levels in the case of over-water nests. Both of these factors were highly variable. A pothole with sufficient nesting sites for a large number of pairs one year may, because of changes in water levels, be entirely unsuitable for any nesting the next. On the study area, over-water nesting cover did not appear to be a critical item. The productivity of the two most abundant over-water nesting species, the redhead and mallard, increased in 1952 in spite of the reduction of hardstem bulrush nesting cover due to flooding.

Broods preferred open-water areas and deep marshes, and there was a minimum of friction between broods even where there were heavy local concentrations.

In such a region, with its ample supply of "brood potholes" and nesting cover, it appears that the limiting factor is probably the space necessary to the spring dispersal of pairs. A shortage of this item is not measurable in terms of ducklings lost or eggs destroyed, but results in unlaid eggs, deserted nests, or perhaps hens careless in their nesting.

As an illustration, once her embryo has started development, a female mammal will generally produce young, barring excessive malnutrition, disease, or serious accident. A bird, on the other hand, if psychologically or physiologically disturbed during egg laying and incubation, might leave her clutch at any time and end that particular nesting attempt. Once hatched, most of the young will reach flying age, barring excessive drought or predation. Two studies (Bue et al., 1952; Evans et al., 1952) have shown that under near-normal conditions mortality of young is about 10 percent. Under similar conditions, nest mortality may be expected to be considerably higher. The period when the habitat may be expected to have the most influence on reproductive success is the early spring when the pair is together and for the following few weeks while the bulk of the hens are incubating. At Waubay, during the four years of the study, this has been from early May through most of July (figs. 12-13). Figures 9-10 show that this has been the period when the greatest number of potholes were filled, and the carrying capacity for pairs was at its peak.

EFFECT OF THE PRESENT DRAINAGE PROGRAM ON DUCK PRODUCTION

Drainage program

Drainage on the Waubay study area and in similar country is now a matter of draining potholes from a relatively high elevation into lower-lying basins; very little of the water actually leaves the vicinity. Seldom is the drained pothole as large as the one that receives the water, and the average size of the 39 that have been drained under the present program is 0.7 acres. Figure 22 shows the pattern of drainage on a part of the Waubay study area. A few additional potholes were drained or partially drained, before the present subsidy-payment program, which began in South Dakota in 1944.

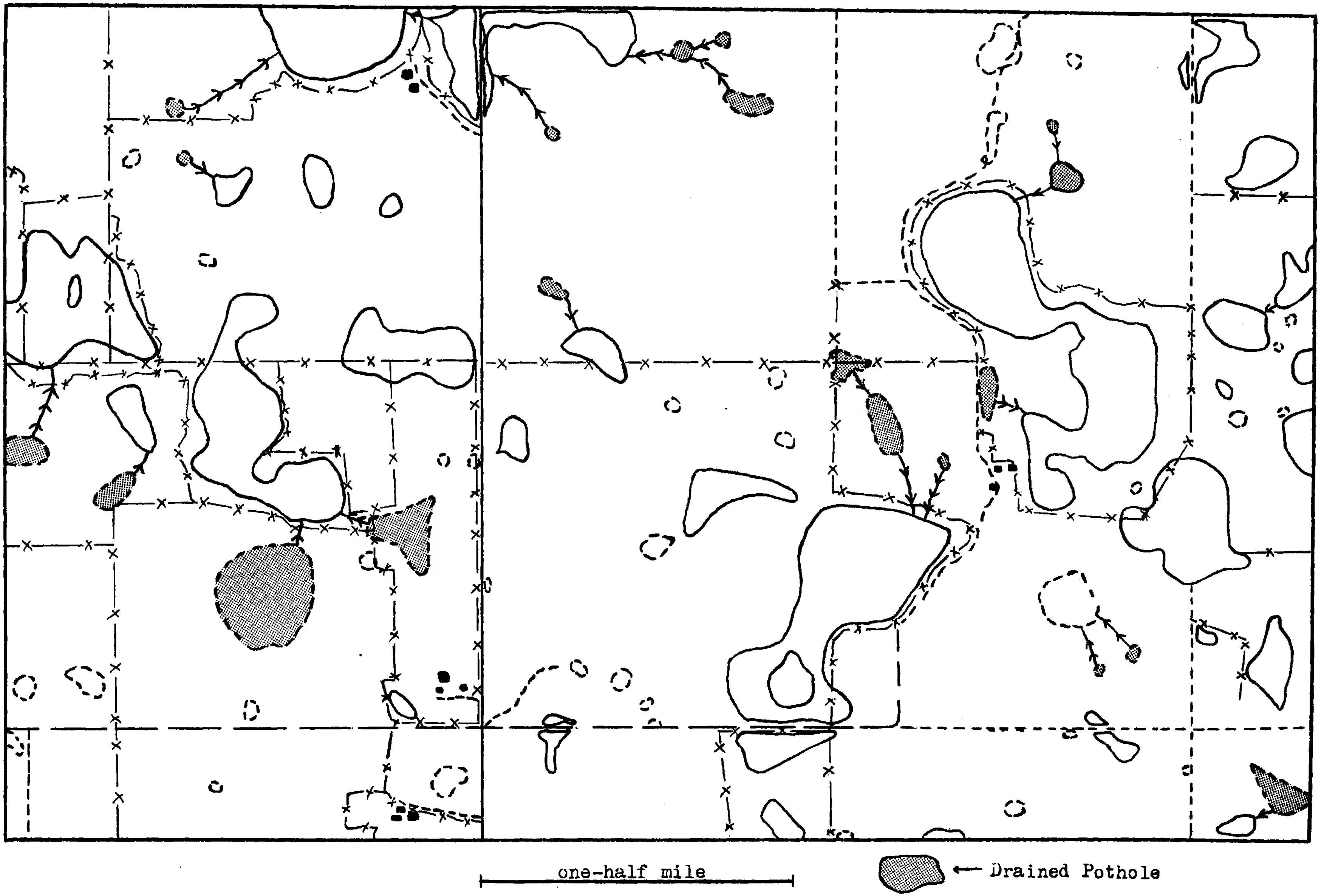

Figure 22.--PATTERN OF DRAINAGE ON A PART OF THE WAUBAY STUDY AREA.

Most of the potholes drained under the present program were temporary and of rather small size. The statement is often made that such drainage "improves" the pothole into which the ditch runs. Although this may sometimes be true in other areas, no evidence of it has been found at Waubay. In general, the relatively small volume of water drained has had little effect on the larger, deeper basins that received it, while the area of water and the number of potholes available during the nesting season have been reduced.

Drainage since 1945 has reduced the original number of potholes on the study area by 9 percent and the original acreage by 3 percent. This is slightly less than the reduction in number of potholes of roughly 10 percent from 1945 to 1950 in the three-state area of the Dakotas and Minnesota reported in Nord et al. (1951).

Effect on brood habitat

Rearing potholes on the study area and in the surrounding country have been ample to supply the needs of the broods produced throughout the four years of the study. Even in 1950, the driest year, there was no evidence that broods were forced to use unsuitable habitat or to become excessively crowded into the better areas. The ability of the broods to move overland enabled them to make full use of the most favorable areas, and there is no indication that possible "improvement" of additional areas could have had any beneficial effect.

Effect on nesting cover

Since the drainage program is eliminating many potholes of the marsh type which contain the most abundant emergent vegetation, over-water nesting habitat is being reduced. While there is no evidence that the reduction that had already taken place has had a harmful effect, there is no question but that its continuance can become harmful.

The same statements may be made with regard to the dryland nesting cover furnished by the bottoms of those potholes which dry up before the nesting season.

Effect on habitat for breeding pairs

Since all types of water areas are used by breeding pairs, drainage of any water is harmful to this phase of the breeding cycle. The drainage of a large "brood area" in a region where such areas are abundant may not be harmful during the brood season, but such areas are also used by breeding pairs in the spring. An increase in carrying capacity would necessitate breaking up the larger areas into small units, rather than the reverse, as is being done. Each pothole drained necessitates either a further concentration of the breeding population with a probable resulting decrease in productivity, or a reduction in the size of the breeding population. Stoudt (1950, 1951, 1952), in discussing trends in breeding population for South Dakota in 1950, 1951, and 1952, concludes that breeding population will be reduced. This is borne out by figure 23 which shows the relation between numbers of water areas available

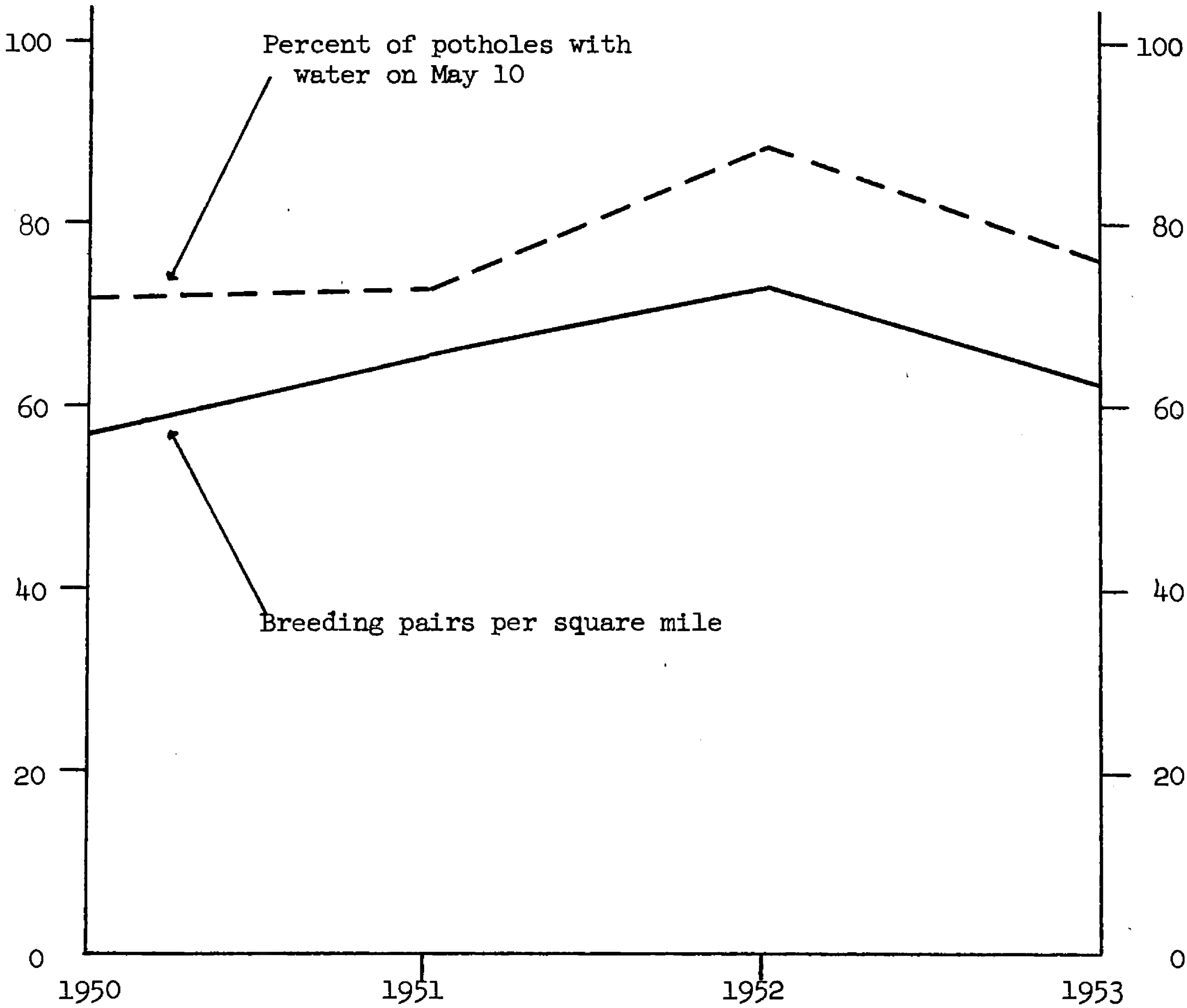

Figure 23.--AVAILABLE WATER AREAS AND DUCK BREEDING POPULATIONS, 1950-53.

in the spring and the size of the breeding population for the four years of the study. These variations in numbers of water areas are, of course, the result of varying degrees of drought, but drought parallels the present-day pattern of drainage (that is, the smaller more temporary potholes are the first to go dry and the first to be drained, followed by those next in order of permanence).

CONCLUSIONS

The preceding discussion has dealt with three major questions: What is the value of typical pothole country to ducks? What are the relative values of the various pothole types? What is the effect of the pothole-drainage program on ducks?

Value of the study area as production habitat

The study area has considerable value to ducks: in the four years of the study, there was an average annual production of 140 young ducks per square mile. Although the productivity of the individual pairs resident on the area in the spring was low, about one young per breeding adult, there is not enough known about the previous history of these birds to conclude that this is due to weaknesses in the habitat itself. Many of the birds arrive rather late in the season, and Stoudt[3] points out that many birds that nest in the James River Valley early in the spring are later forced to leave as their nests are destroyed by agriculture and as the water areas dry up. It is probable that many of the pairs using the Waubay area for nesting are these same birds and already have had their productivity reduced by at least one unsuccessful nesting attempt. The fact remains that on a square-mile basis there were considerable numbers of young produced here.

Relative values of pothole types

The general statement may be made that on an area basis, all types of potholes are of practically equal value. The small temporaries are of no value through most of the year but, acre for acre of water, they are the most valuable type during the critical breeding period. The large permanent areas serve a number of functions in duck production through a much longer period, but do not have as high a value during the breeding season. Furthermore, as water levels, weather, and duck populations fluctuate, the birds vary their use of the habitat, further equalizing the long-term values of the different types.

Effect of the drainage program on ducks

Drainage of any water area reduces both the total number and the aggregate area of potholes and has an adverse effect on duck production, particularly as it relates to the carrying capacity of the habitat for breeding pairs. There is no phase of the reproductive cycle that can be shown to benefit by this program, regardless of claims that brood areas are improved by it.

It should also be pointed out that the public funds that are contributing, through drainage of potholes, to the elimination of a valuable national resource are also contributing to the maintenance of a form of agriculture that many believe to be detrimental to the economic future of the region. Agricultural authorities and soil conservationists have stated that the best use of this land is the raising of grass and cover crops. Anything that helps to perpetuate the present type of farming, row crops and small grains, is only delaying the ultimate shift to a better use of the land.

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[3] Stoudt, J. H. 1950. Letter to the Director, U.S. Fish and Wildlife Service, relating to the 1950 breeding-ground survey.

APPENDIX--METHODS

Census

Much of the information gathered from the study area is related to size and condition of the waterfowl population. Since the value of the information depends largely on the accuracy of census, the methods used are described in detail.

In the spring, before the broods had hatched, census of the adult birds was a fairly simple matter and involved merely walking around the margins of potholes, or once or twice through large overgrown areas to flush the birds.

Since the study area is rectangular, rather than a linear transect, the major problem was to avoid duplicate counts of birds. By observing where a bird alighted after it was flushed from a pothole, the counter could eliminate it from counts made at the place where it settled. The problem was somewhat simplified by leaving potholes with large numbers of birds until late in the day. Whenever possible, birds on bare shores, where they could easily be seen, were not flushed. By using these methods, duplicate counts were kept to a minimum. Because of daily movements of birds across the boundaries of the study area, it was not intended that each bird be recorded as a resident. However, it is assumed that an index to the population density of each species was obtained.

Birds were recorded as "pairs," "lone drakes," "lone hens," and "gathered birds" (presumably not breeding). For purposes of determining the breeding population in terms of breeding units or pairs, each pair, lone drake, and lone hen was assumed to represent a nesting pair. Undoubtedly some pairs were missed through not counting some of the grouped drakes, but it was impossible to determine which drakes had merely left their hens temporarily and which were through breeding for the season. The error was kept to a minimum by estimating the spring breeding population for each species separately. The breeding population of all species is the sum of the peak number of breeding units of each species regardless of the time each peak occurs. A chance for error in this method of calculation lies in the possibility of pairs moving onto the area after the peak date. These late arrivals could not be added to earlier totals for the species. However, it is believed that very few birds arrived after the peak date. Another possibility for error is that some pairs might have broken up before the peak date, the drake to join other drakes and the hen invisible on the nest. Again, it is believed that little of this occurred before the species was present in peak numbers. The effects of these factors are evaluated in the section "Nesting Population."

With the advent of the brood season, the difficulties of census increased. The habits of the brood hens and the young of the puddle ducks created a new problem, since many tried to hide rather than to flush into the open. A few attempted to escape overland.

Most brood-census work was carried out as shown in figure 24 (A). A two-man crew started on one side of a pothole and zigzagged around opposite

sides, swinging at least 20 feet up on dry shore and out beyond the emergent vegetation. Before the two men met at the far side, the broods had usually broken out into the open where they could be counted. The swings up on dry shore were to discourage the broods from doubling back around the beaters on the shoreward side of the vegetation. Although there are many regions where broods spend much time on the uplands, four years of continuous foot travel, two of them with a dog, found no broods more than 20 yards from a water area at Waubay, except those few that had attempted escape overland during the "beat-out".

On large overgrown areas, broods were driven into one end by both men zigzagging back and forth across the pothole, working toward the far end as shown in figure 24 (B). When the broods were forced into one end, the hens would flush, giving away the presence of their broods by feigning injury. There were often enough young captured so that the age of most of the broods could be determined. Most such areas were under 10 acres in size, and it is believed that coverage was good, although censusing of the larger areas by this means may have missed a few broods.

The large open-water potholes which could not be "beaten out" efficiently were censused by concealed observation for an hour or more in the early morning or evening. Provided the weather was calm, these were periods of peak activity

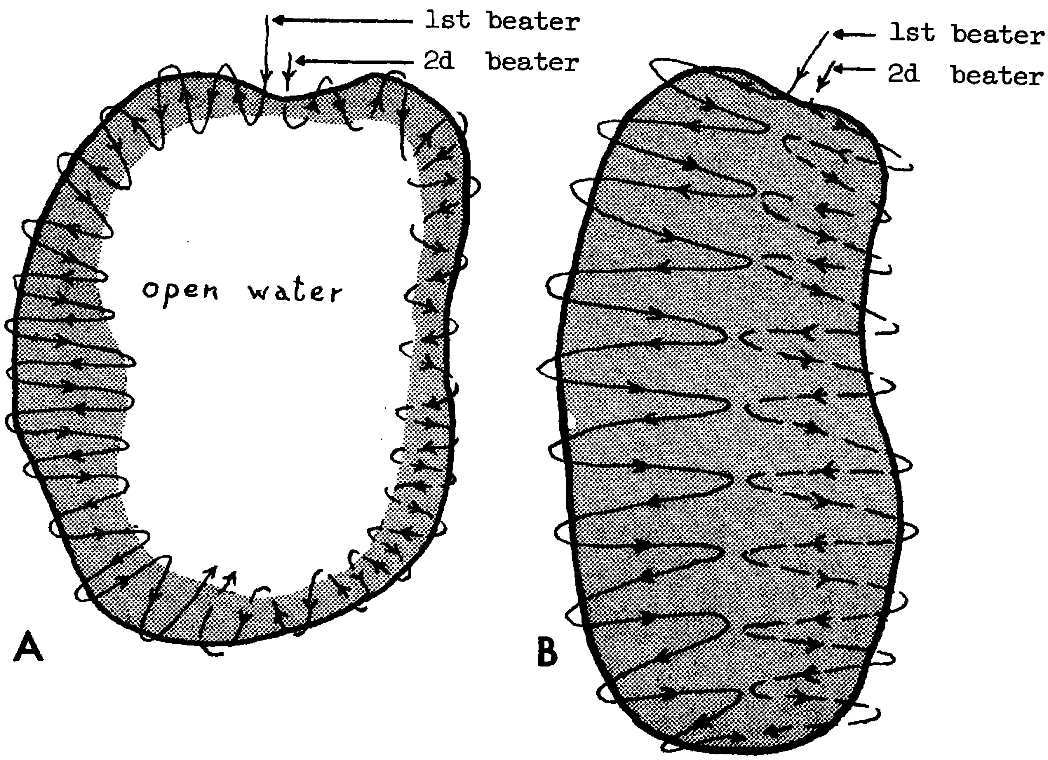

Figure 24.--BEAT-OUT METHOD OF COUNTING BROODS.
A. Beat out of open-water area. B. Beat out of overgrown area.

and broods could be expected to show themselves if not disturbed during the waiting period. No attempt was made to approach the pothole without disturbing the birds, as this was found to be impossible. If the observer then concealed himself or remained absolutely still, activity generally was resumed within 30 minutes of his arrival. Depending on water levels, vegetation, and available personnel, from 20 to 45 potholes were censused in this manner on each coverage of the study area. These contained over three-fourths of the broods seen.

In 1951 and 1952, a Labrador retriever was used to assist in finding broods. The dog was generally kept under close control during the zigzag "beat-out" and was allowed freedom at the end to flush, but not to chase the birds. He was later sent up on shore to make sure that none had escaped overland. These he was allowed to chase as they were difficult to find otherwise. The dog was almost a necessity in 1951 and 1952, since water levels were high and many of the overgrown areas contained water throughout the brood season. In 1950, most overgrown areas were dry, or nearly so, before many broods had hatched. Open-water areas in this region could be well covered without the dog, provided care was taken to discourage broods from going ashore.

Brood census was not attempted in winds much over 15 miles an hour, because of the difficulty in driving the birds.

In general, it is believed that the coverage for broods was nearly complete, but it should be noted that the production figures for the study area represent a minimum.

Late-summer and fall counts of adults and flying juveniles were also made in conjunction with brood counts. Since these were made mainly for the purpose of determining utilization, only rough estimates were made of populations of flying birds, and no attempt was made to separate adults from juveniles. Thirty complete coverages of the study area have been made: eight in 1950, ten in 1951, six in 1952, and six in 1953. Twelve additional coverages of a 2-square-mile area were made in the summer of 1950, and five extra coverages were made of a 1-square-mile area in the spring of 1951.

Other data

Records were kept throughout the season of each year on the depth of each pothole whenever it was visited.

During the late summer and fall of 1950, rough cover maps were made of each pothole. In subsequent years, notes were taken on the condition of the vegetation at the time of each visit. These were simple and included a rough estimate of the width of each band of vegetation, its predominant species, and density.

Using the data on water levels and vegetation, it was possible to modify the original classification developed by Bach (1952), which depended on permanence, to conform more closely to that developed by the Wetland Classification Committee (Martin et al. 1953).

In order to gain information on the habits of birds, considerable time was spent in marking individuals so that they could be readily recognized in the field. Most of this work dealt with the marking of broods in order to study the relations of the nest to brood water. This was done mainly by marking the young with aniline dyes injected into the egg as described by Evans (1951). In addition to this, hens were trapped at the nest and marked on the wings with airplane dope to give a larger number of combinations so that more individuals could be identified without possibility of confusion. This method has been described by Sowls (1950).

Considerable time was spent developing a method for capturing breeding adults during the courtship and nesting period so that they could be marked for recognition. The method was based on a modification of the cannon-projected net trap described by Dill and Thornsberry (1950).

An outfit was made up using two cannons similar to those of Dill and Thornsberry, but using black powder as a propellant and a black powder electric squib as the "primer" (Black and Evans, 1953).

The trap was set up on the margin of a pothole facing out over the water with the net just at the water's edge. Baiting with food was ineffective during the nesting season, and as a means of localizing birds in front of the trap, a log about 2 feet long was set out at each trapping site about in the center of the extended net. The log served as an attractive loafing site for the birds and as an aiming point for determining when to fire on birds cruising along the shore.

In 1952, eight blue-winged teal and a mallard drake were captured and marked with model-airplane dope. Better equipment in 1953 led to the capture and marking with plastic neckbands of 17 blue-winged teal. Considerable difficulty was experienced in locating the marked birds and only 157 observations were made. Of the 26 birds marked, 6 were never seen again. Observations of the remaining 20 indicated that it was unlikely they were frightened from the area by the cannon, as many were disturbed so little that they returned to the trapping area within a day or two of their capture. These six birds not subsequently observed were probably either not yet settled on the area or were captured at the extreme edge of their range.

Analysis of production

Each square mile of the area was censused for broods at least once every 35 days and it was assumed that all broods were counted. The main difficulty in getting a reliable figure lay in the elimination of duplicate counts of individual broods that moved from pothole to pothole. This was done by carefully aging all broods seen and eliminating from the tally all those old enough to have been tallied on a previous count. The method is described in Blankenship et al. (1953).

Information on the ages of all broods on the study area was used not only for determining the production of young, but also for working out the chronology

of the breeding season by back-dating broods to the start of the clutch. Since each brood was tallied only once and there was constant intensity of census (100 percent) throughout the season, this method gave a better picture of the nesting season as regards successful nests than would a study of the nests themselves.

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